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ACTA RADIOLOGICA

OFFICIAL ORGAN OF THE RADIOLOGICAL SOCIETIES OF
DENMARK, FINLAND, NORWAY AND SWEDEN

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COLOUR IN SUBTRACTION ANGIOGRAPHY

Preliminary report

by

B. LILIEQUIST and U. WELANDER

DJINDIAN suggested the use of radiographic subtraction by colour addition in angiography. The basic principles of this technique is that when two complementary colours of monochromatic light are mixed, the resultant light will be white. This means that if two exactly alike roentgenograms are projected together through *separate filters of complementary colours*, the image will be totally extinguished. If the two roentgenograms are not exactly alike, *the difference* will show up in one of the colours, depending on in which film it occurs. With colour addition and by combining two different angiograms from the same angiographic series it is thus possible simultaneously to achieve subtraction of skeletal structures and obtain a subtraction angiogram (FREY & NORMAN 1965, SCHWARTZ 1966, WISE & GANSON 1965).

A further development of this subtraction technique has been made by OOSTERKAMP (1966). A colour TV set was used to combine three *roentgenograms*, two bearing information and the third a masking film for the subtraction. The colour TV had three screens, a red, a blue, and a green. The colours are well defined and so selected that any combination of the same amount of two colours will always provide the colour complementary to the third.

If one angiogram is projected on the red screen and another on the blue

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screen, the skeletal structures will be coloured in a mixture of red and blue which is magenta By the projection of a conventional roentgenogram from one and the same angiographic series on the green screen, it is possible to make subtraction of bone structures simultaneously in the red and blue images The vessels will thus be coloured red and blue and in the ideal case will be seen against a neutral background

The use of colour in angiography is considered to offer a good method of demonstrating, in the same image, the relation between arteries, veins and tumour densities as well as the displacement of vessels The usefulness of the method in teaching has been stressed DECKER et coll (1967, 1968) have preliminarily tested the colour TV method for producing colour angiograms and predict good future results Certain of the colour angiograms presented by DECKER & BACHMUND had however been photographically produced on colour film with the aid of filters

An investigation is now in progress, using a method developed by WELANDER, with a view to assess the value of colour in the angiographic diagnosis The photographic subtraction of angiograms is first made in black and white according to conventional methods the subtraction angiograms are then bleached and redeveloped in different colours (yellow, magenta, and cyan) by a photochemical process Kodachrome developers are used, but the original processing method has been considerably modified Three angiograms of the same series representing different phases of circulation are coloured, when combined, the vessels will appear in successively changing colours depending on whether they are present in one, two or all of the three subtraction films

We have not been able to trace any investigation in which a successive colour change in the vessels has been matched to the flow of the contrast medium or in which the information presented by the three angiograms has been combined

Results

These must be regarded as preliminary Three successive films from a rapid serial carotid angiography coloured according to the new technique are presented in Fig 1

The circulation in the different branches can be followed by noting the successive colour changes that appear in the following order yellow red magenta blue and cyan The colours express the relative time of circulation through different parts of the brain In other words, the same phase of circulation in any vessel is expressed by the same specific colour, and this makes it possible to compare the contrast medium flow through the different carotid artery branches

By observing the colours it is possible to study very small changes in the flow of the contrast medium, such as differences between angiograms of the capillary

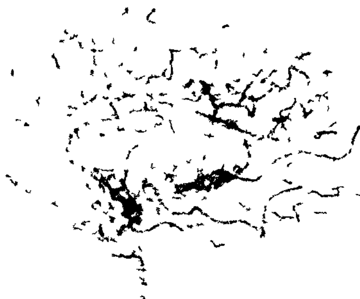


Fig 1 Three combined serial angiograms of the internal carotid artery in a normal case covering the complete arterial phase the capillary phase and the beginning of the venous phase

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phase exposed at intervals of 1/6 of a second The circulation to the peripheral parts in the frontopolar anterior cerebral and pericallosal arteries, where the distal branches are red is for example faster than in the medial and posterior cerebral arteries where the distal parts are magenta and blue The capillary phase appears earlier in the frontal part of the brain than in the parietal and occipital parts the latter are coloured blue indicating that the capillary phase is present both in the magenta and the cyan coloured films Early filling veins appear in cyan because they were outlined at the end of the two seconds of circulation covered by the films

A fast circulation through multiple metastases in the brain is depicted in Fig 2 in which the circulation time covered is one second The tumour densities appear in different colours which makes it possible to decide the order of filling Drainage veins are demonstrable from nearly all metastases and have a bluish tone this is an expression of their presence in both the cyan and the magenta coloured films The drainage vein from red coloured tumour density originates in the posterior part

SUMMARY

A new technique of colour subtraction angiography for studying relative differences in the circulation time betwe n separate parts of an organ is described This method should permit the determination of the fast as well as the slow circulation even in the smallest vessels and a simultaneous demonstration of the drainage veins

ZUSAMMENFASSUNG

Eine neue Technik fur Farbsubtraktions-Angiographie wird beschrieben mit der es moglich ist den relativen Unterschied der Zirkulationsgeschwindi keit in den einzelnen Teilen eines Organs zu studierten Man durfte mit die er Methode die kurzen so we die langeren Zirkulationszeiten auch in den kleinsten Gefassen observieren konnen und gleichzeitig die Dranagevenen darstellen konnen

RÉSUMÉ

Les auteurs decrivent une nouvelle technique de soustraction en couleur appliquee à l angiographie pour etudier les differences de vitesse circulatoire dans les differentes parties d un organe Cette methode devrait permettre d indiquer la vitesse circulatoire meme dans les plus petits vaisseaux et en meme temps mettre en evidence les veines de drainage

REFERENCES

DECKER K und BACHMUND H Angiographie des Hirnkreislaufs Georg Thieme Verlag Stuttgart 1968

— LINCKE H O und OOSTERKAMP W J Die Beurteilung von Rontgenbildern und ihre Erleichterung durch Farbsubtraktion S 78 Deutscher Rontgenkongress Baden Baden 1967



Fig 2 Circulation through multiple metastases of the brain depicted by successive colour changes obtained by combining three coloured angiograms of the same angiographic series

FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR KJELL LIVERUD) THE NORWEGIAN RADIUM HOSPITAL, OSLO NORWAY

VIDEO TAPE RECORDING IN SELECTIVE CATHETERIZATION

by

TOR DREVVATNE

Selective angiography is usually performed with a curved roentgen-opaque catheter anatomic knowledge being used to position the tip in the desired vessel A preliminary aortogram may be obtained to indicate any possible variations in the vascularity and to make the selective catheterization easier, the vessel to be examined is localized in relation to certain vertebral bodies or other fixed references Selective catheterization performed in this way is generally successful but must necessarily depend upon the routine and to some extent on a certain amount of luck

The fact that an aortogram is often preferred for the orientation indicates the necessity for an individual map of the vessels this should preferably be projected on the same TV monitor as the fluoroscopic image during selective catheterization and may be achieved by using some type of electronic memory In the method to be described a video tape recorder connected via an electronic control unit to the image intensifier and the TV monitor is used A catheter is introduced in the usual manner into the aorta with the tip at the level of the artery to be examined

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OOSTERKAMP W J Progress in recording the radiographic image Medica mundi 11 (1966), 117
— VAN T HOF A P M und SCHEREN W J L Rontgenfarbbilder neue Moglichkeiten der Subtraktion durch die Fernsehtechnik, S 168 Deutscher Rontgenkongress Berlin 1966
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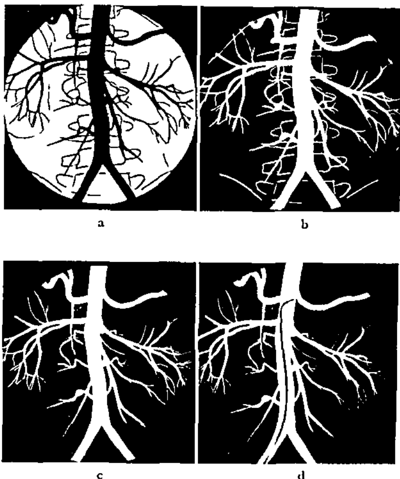


Fig. 1. Schematical drawings. a) Aortogram arrested on video tape. b) Signal inverted. c) Fluoroscopy switched on: subtraction. d) Catheter in aorta.

The contrast medium is injected as for an ordinary aortogram with an automatic syringe to give sufficient filling of the aorta. The syringe is so connected that the injection is made without release of the film changer; the flow of the medium is followed on the TV monitor.

When optimal contrast filling of the aorta and its branches has been obtained the image is arrested on the non-moving tape by means of a foot switch (Fig. 1a). This image is then inverted by the control unit (Fig. 1b). Switching on of fluoroscopy produces electronic subtraction, the running positive signal from the image intensifier being subtracted from the previously inverted signal from the tape recorder. As a result, the aorta and its branches appear white against a neutral background (Fig. 1c).

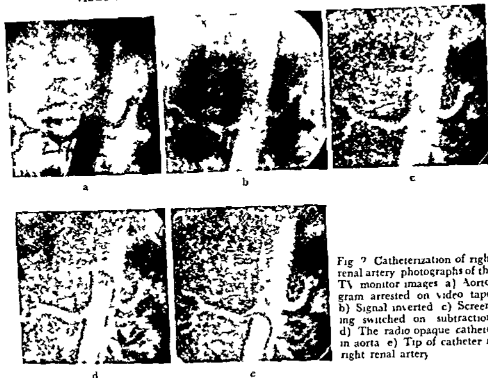


Fig 2 Catheterization of right renal artery photographs of the TV monitor images a) Aortogram arrested on video tape b) Signal inverted c) Screening switched on subtraction d) The radio opaque catheter in aorta e) Tip of catheter in right renal artery

A radio-opaque catheter introduced in the aorta is seen as a grey catheter in a white aorta (Fig 1d) The movements of the tip of the catheter can be followed so that the catheter is easily manoeuvred into the ostium of the vessel to be examined (Fig 2)

The image is recorded and played back onto the non moving tape As the recorded image will remain on the video tape for about an hour, there will be sufficient time for selective catheterization

A normal TV image lasts 0 04 seconds and is made up of 625 lines, 312 and a half lines of which appear in each half picture alternating between lines 1—3—5 and 2—4—6

We use a Philips video tape recorder the head of which rotates at a speed of 0 02 seconds and records only a half picture The video tape signal is synchronized with the signal from the image intensifier by changing the system to 630 lines 315 of which make up one half picture During subtraction one signal emerges from the tape recorder in inverted form the other signal coming from the image intensifier and both appear on lines 1—3—5 the subtraction is made electronically before the image appears on the monitor

SUMMARY

A method of performing selective catheterization with a video tape recorder connected to an image intensifier and TV monitor is described.

ZUSAMMENFASSUNG

Eine Methode fur die Durchfuhrung der selektiven Katheterisierung mit Hilfe von einem Videobandschreiber in Verbindung mit Bildverstarker und Fernsehmonitor wird beschrieben.

RÉSUMÉ

L'auteur décrit une methode de cathétérisme sélective avec enregistrement de l'image sur une bande magnetique (video tape recorder) couplé à un amplificateur d'image et à un TV monitor.

FROM ROENTGEN DEPARTMENT I (DIRECTOR O BARTLEY) AND MEDICAL DEPARTMENT I (DIRECTOR L WERKO) SAHLGRENSKA SJUKHUSET, GOTHENBURG SWEDEN

RENAL FUNCTION BEFORE AND AFTER UROGRAPHY AND ANGIOGRAPHY WITH LARGE DOSES OF CONTRAST MEDIA

by

O BARTLEY, U BENGTSSON and G CEDERBOM

The roentgen contrast media for vascular use during the early fifties were the diiodized compounds (e g Perabrodil Diiodone Diodrast, Perjodal and Umbradil) A number of cases with signs of impairment of renal function following angiography or urography with some of these media have been reported (ALWALL et coll 1955 IDBOHRN 1956, EDLING & HELANDER 1957 CRAWFORD et coll 1957 ALWALL 1963) During later years triiodized contrast media have replaced the diiodized media some of the most frequently used being either diatrizoate compounds such as Hypaque Urografin, Renografin, or metrizoate compounds such as Isopaque Only a few cases of renal damage attributed to their use have been published (BERLYNE & BERLYNE 1962, ALWALL 1963) Animal experiments have indicated that the newer media are considerably less nephrotoxic than those earlier employed (McCHESNEY & HOPPE 1957 BERG et coll 1958 KILLEN et coll 1960, LINDGREN 1961 STOKES & BERNARD 1961)

The triiodized contrast media seem to be excreted almost entirely by glomer

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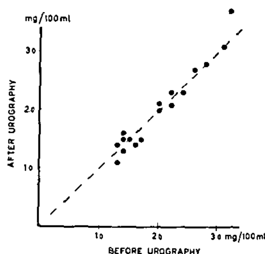


Fig 1 Serum creatinine concentrations in 17 patients before and after urography

ular filtration (WOODRUFF & MALVIN 1960) In an earlier study (BARTLEY et coll 1968) good correlation was obtained between the serum creatinine concentration and the data of the urographic excretion rate and the filling and density of the medium By using 40 ml Urografin 60 % it was possible to obtain diagnostic urographies in two thirds of the number of patients with serum creatinine values between 2 7 and 3 3 mg/100 ml, but only occasionally above this level It would therefore appear desirable to use higher doses of media in patients with marked renal impairment so as to obtain diagnostic urographies

The aim of the present investigation was to study whether large doses of media cause renal damage or render such an existing condition worse Renal function studies were performed before and after intravascular administration of the doses

Material and Methods The material comprised 43 patients Urography was performed in 17 and angiography in 26 of them

In the urography series comprising sixteen women and one man, the mean age was 57 years (range 31 to 89 years) All the patients suffered from chronic pyelonephritis In addition, renal papillary necrosis was present in eight of the patients

In the angiography series comprising eleven women and fifteen men the mean age was 58 (range 40 to 75 years) Nineteen patients were examined by nephroangiography for probable or proven renal disease mostly malignancy Four patients underwent venous arteriography and three were subjected to pelvic femoral angiography no diagnosis of renal disease had been made

The renal function was estimated from the serum creatinine concentration

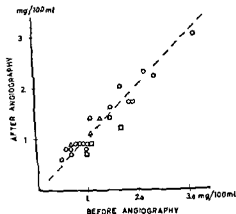


Fig. 2. Serum creatinine concentrations before and after angiography. ○ nephroangiography; □ venous arteriography; △ peripheral arteriography.

The serum creatinine was assayed by the method of BONSNES & TAUSSKY (1945) and a value of 1.2 mg/100 ml was considered the upper normal limit. The renal concentrating capacity was determined after intramuscular injection of pitressin tannate in oil (5 pressure units) by the method of DE WARDENER (1958) as modified by BENGTSSON et coll. (1964). A urine concentration of 800 mOsm/kg H O was set as the lower normal limit in middle aged subjects and 700 above 60 years of age. The serum creatinine level was determined in all patients whereas the renal concentrating capacity was studied in ten of the patients in the angiography series. The renal function tests were carried out within one week before and one week after the roentgenographic examination.

The urographies were performed by injection of a 60 % triiodized contrast medium. The following quantities were used: 40 ml with a serum creatinine level below 2.0 mg/100 ml, 60 to 80 ml with creatinine values between 2.0 and 3.0 mg/100 ml and 100 ml above 3 mg/100 ml. The routine technique with ureteral compression was employed.

Sixty millilitre of the contrast medium was injected in all the nephroangiographies. Selective renal arteriography was also performed in two of the patients by an additional injection of 7 ml of the contrast medium. In three other patients 30 ml was added to obtain selective coeliac angiography. The venous arteriographies were performed with 2 × 100 ml contrast medium injected into the inferior vena cava immediately caudal to the right atrium. The quantity of the medium in the peripheral angiographies varied between 180 and 220 ml. Urografin mostly 60 % was used in all the examinations in this material, exceptions were the venous arteriographies in which the 76 % and three of the peripheral angiographies in which the 45 % solutions were employed.

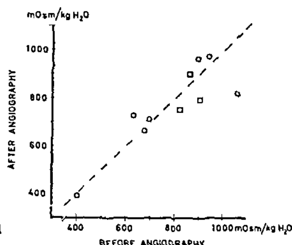


Fig 3 Maximum urine osmolality before and after angiography Same symbols as in fig 2

Percutaneous puncture with the catheter technique was the rule for angiography

Results

Urography The results of the serum creatinine determinations before and after urography in seventeen patients with chronic pyelonephritis are shown in Fig 1 Before the investigation all the patients had an elevated creatinine value ranging from 1 3 to 3 3 mg/100 ml After urography, no consistent change was observed and the serum creatinine averaged 2 0 mg/100 ml both before and after the examination

Angiography The serum creatinine values before and after angiography in twenty six patients are presented graphically in Fig 2 Before angiography, the serum creatinine was within normal limits in sixteen of the patients and averaged 0 9 mg/100 ml (range 0 5 to 1 1) Elevated figures, averaging 1 9 mg/100 ml (1 3 to 3 2), were present in ten patients before angiography Following angiography, no consistent change occurred in the serum creatinine The mean value remained unchanged both in the group with a normal value and in the group with an elevated figure before angiography

The renal concentrating capacity before and after angiography in ten patients is given in Fig 3 Before the examination the osmolality values were within normal limits in six patients, the range being 815 to 1 055 mOsm/kg H O, and reduced in four patients to 400 to 690 mOsm/kg H_2O Following angiography, no obvious changes in osmolality were observed except in one subject in whom the figure had decreased from 1 055 to 815 mOsm/kg H_2O

The mean value in the group as a whole was 784 before and 769 mOsm/kg H_2O after the investigation

Discussion

The patients in the present study were in a clinically steady state at the time of investigation Reports in the literature on renal damage after urography or angiography usually include little data about the renal state before the roentgen examination The possibility may always arise that an acute exacerbation of an underlying disease may have coincided with the examination, so it may be difficult to analyze the role played by the contrast medium

Most of the reports of renal damage attributed to a nephrotoxic effect of contrast media stem from the use of the diiodized substances, which have nowadays been discarded A causal relation between the injected medium and the renal damage has not been established in several of the cases reported Some reports on induced renal failure have included cases examined by retrograde pyelography (PENDERGRASS et coll 1942 FIGDOR 1956, ALWALL 1963) and fever has been a frequent symptom Subsequent pyelonephritis sometimes appeared to be the cause of deterioration in renal function On the other hand there are undoubtedly cases of renal damage caused by the contrast media previously used

There are only a few reports on renal damage following the use of the newer triiodized media (BERLYNE & BERLYNE 1962 ALWALL 1963) The role played by the medium cannot be judged in any of the cases the case of BERLYNE & BERLYNE had a blood pressure fall during 24 hours and ALWALL gave no details about his case

Some authors have considered that all media used intravascularly carry a risk when renal insufficiency is present (PENDERGRASS et coll 1955, ALWALL et coll 1955 IDBOHRN 1956 EDLING & HELANDER 1957 OLSSON 1963) On the other hand SCHWARTZ et coll (1963) used 60 to 100 ml of a triiodized contrast medium without noting any deleterious effect on the kidney (as estimated from the serum creatinine concentration) even in cases of renal insufficiency Similar experiences were reported by FRIEDENBERG & CARLIN (1964) and BISHOP et coll (1964) Thus the results of the creatinine determinations in the present study confirm the results of these authors

Even if the above mentioned studies have given no evidence of renal damage caused by contrast media it cannot be excluded for two reasons (1) serum creatinine is not a precise index of glomerular filtration rate, although it is a better means of evaluating glomerular function than the blood urea nitrogen and nonprotein nitrogen tests and (2) nephrotoxicity often involves the tubules in the first instance

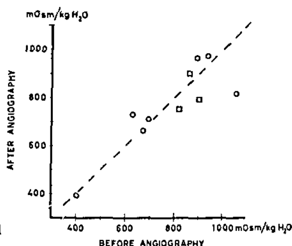


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Most of the reports of renal damage attributed to a nephrotoxic effect of contrast media stem from the use of the diiodized substances, which have nowadays been discarded A causal relation between the injected medium and the renal damage has not been established in several of the cases report ed Some reports on induced renal failure have included cases examined by retrograde pyelography (PENDERGRASS et coll 1942, FIGDOR 1956, ALWALL 1963) and fever has been a frequent symptom Subsequent pyelonephritis some times appeared to be the cause of deterioration in renal function On the other hand there are undoubtedly cases of renal damage caused by the contrast media previously used

There are only a few reports on renal damage following the use of the newer triiodized media (BERLYNE & BERLYNE 1962 ALWALL 1963) The role played by the medium cannot be judged in any of the cases the case of BERLYNE & BERLYNE had a blood pressure fall during 24 hours and ALWALL gave no details about his case

Some authors have considered that all media used intravascularly carry a risk when renal insufficiency is present (PENDERGRASS et coll 1955 ALWALL et coll 1955 IDBOHRN 1956, EDLING & HELANDER 1957, OLSSON 1963) On the other hand SCHWARTZ et coll (1963) used 60 to 100 ml of a triiodized contrast medium without noting any deleterious effect on the kidney (as estimated from the serum creatinine concentration) even in cases of renal insufficiency Similar experiences were reported by FRIEDENBERG & CARLIN (1964) and BISHOP et coll (1964) Thus the results of the creatinine determinations in the present study confirm the results of these authors

Even if the above mentioned studies have given no evidence of renal damage caused by contrast media it cannot be excluded for two reasons (1) serum creatinine is not a precise index of glomerular filtration rate, although it is a better means of evaluating glomerular function than the blood urea nitrogen and nonprotein nitrogen tests and (2) nephrotoxicity often involves the tubules in the first instance

In order to assess the renal function more closely, the present study was complemented with elaborate clearance studies before and after large doses of contrast media in patients with advanced renal impairment No changes were demonstrated (BENGTSSON et coll 1968)

Tubular function tests have not earlier been performed in the study of renal effects from contrast media Such examinations were therefore included in the present study Tubular function is most easily and reliably estimated from the concentrating capacity after administration of pitressin tannate This test has a good reproducibility The maximum values seldom varied more than 50 mOsm/kg H_2O in patients with renal disease (BENGTSSON 1962) The maximum osmolality seemed to vary more in healthy individuals (HOOD et coll 1965) The only patient in the present study with a noticable decrease of maximum osmolality after the roentgen examination had a normal function The value was still within the normal range even after the decrease, thus, there was no evidence of imposed tubular damage

The majority of patients of the present series with renal insufficiency had chronic pyelonephritis Myeloma has been considered a special risk, and a specific reaction between the myeloma kidney and contrast media has been suggested (HOLMAN 1939, KILLMAN et coll 1957, MYHRE et coll 1956) However, opinions are divided and some authors have been unable to find any deleterious effect by urography even in large series of this disease (VIX 1966) The present study did not contribute anything to this particular problem

SUMMARY

The renal function was studied in 17 patients before and after urography and in 26 patients before and after angiography using large doses of contrast media The serum creatinine concentration was determined in all the patients and in ten patients also the renal concentrating capacity All the patients in the urography series and ten in the angiography serie had renal insufficiency as judged from the serum creatinine level No changes in the renal function could be demonstrated following administration of the large doses of contrast media

ZUSAMMENFASSUNG

Die Nierenfunktion wurde in 17 Patienten vor und nach Urographie und in 26 Patienten vor und nach Angiographie nach Injektion grosser Dosen von Kontrastmitteln studiert In allen Patienten wurde die Serumkreatininkonzentration und in zehn Patienten auch die Nierenkonzentrationskapazität festgestellt Alle Patienten in der Urographiegruppe und zehn Patienten in der Angiographiegruppe hatten an Niereninsuffizienz wie man es aus den Serumkreatininwerten ersehen konnte Die Nierenfunktion wurde von der Darreichung grosser Dosen von Kontrastmitteln nicht beeinflusst

RÉSUMÉ

Les auteurs ont étudié la fonction rénale chez 17 malades avant et après urographie et chez 26 malades avant et après angiographie avec d'importantes doses de moyen de contraste. La concentration de créatinine sérique était determinée chez tous les malades et chez dix malades aussi la capacité rénale de concentration. Tous les malades qui avaient subi une urographie et dix des malades qui avaient subi une angiographie ont presenté une insuffisance rénale si on en juge par le taux de créatinine sérique. Les auteurs n'ont pu mettre en évidence aucune modification de la fonction rénale après administration d'importantes doses de moyen de contraste.

REFERENCES

ALWALL N. Therapeutic and diagnostic problems in severe renal failure. Scandinavian University Books. Lund 1963.

— ERLANSON P. and TORNBERG A. The clinical course of renal failure occurring after intravenous urography and/or retrograde pyelography. Casuistics of 11 cases (including 7 deaths). Acta med. scand. 152 (1955) 163.

— JOHNSSON S., TORNBERG A. and WERKO L. Acute renal failure following angiography. Acta chir. scand. 109 (1955) 11.

BARTLEY O., BENGTSSON U. and STATTIN S. Urography in relation to renal function. Acta radiol. Diagnosis 7 (1968) 289.

BENGTSSON U. A comparative study of chronic non obstructive pyelonephritis and renal papillary necrosis. Acta med. scand. (1967) Suppl. No. 388.

— FALKHEDEN T. och HOOD B. Rutinprovens värde för tidig funktionsdiagnostik vid njursjukdom (Swedish). Svenska Läk. Tidn. 61 (1964) 906.

— CEDERBOM G., FALKHEDEN T. and JAGENBURG R. Clearances of inulin and para aminohippurate before and after urography using high dosage of contrast medium in patients with renal insufficiency. Scand. J. Urol. Nephrol. 2 (1968) 173.

BERG N. O., IDBOHRN H. and WENDEBERG B. Investigation of the tolerance of the rabbit's kidney to newer contrast media in renal angiography. Acta radiol. 50 (1958) 285.

BERLYNE N. and BERLYNE G. M. Acute renal failure following intravenous pyelography with Hypaque. Acta med. scand. 171 (1962) 39.

BISHOP R. C., HEETDERKS JR. D. R. and STEWART B. H. Excretory urography in the azotemic patient. A revised technique. J. Urol. 91 (1964) 441.

BONSNES R. W. and TAUSKY H. H. On colorimetric determination of creatinine by Jaffé reaction. J. biol. Chem. 158 (1945) 581.

CRAWFORD E. S., BEALL A. C., MOYER J. H. and DE BAKEY M. E. Complications of aortography. Surg. Gynec. Obstet. 104 (1957) 129.

EDLING N. P. G. and HELANDER C. G. On renal damage due to aortography and its prevention by renal tests. Acta radiol. 47 (1957) 473.

FIGDOR P. P. Akute Nierenschaden nach Pyelographien. Z. Urol. 49 (1956) 133.

FRIEDENBERG M. J. and CARLIN M. R. The routine use of higher volumes of contrast material to improve intravenous urography. Radiology 83 (1964) 405.

HOLMAN R. L. Complete anuria due to blockage of renal tubules by protein casts in a case of multiple myeloma. Arch. Path. 27 (1939) 748.

HOOD B., CARLSSON M., FALKHEDEN T. och BENGTSSON U. Ett förkortat törstprov och dess tillförlitlighet (Swedish.) Nord. Med. 74 (1965) 1111.

IDBOHRN H. Tolerance to contrast media in renal angiography. Acta radiol. 45 (1956) 141.

KILLEN D A and LANCE E M Experimental appraisal of the agents employed as angiocardiographic and aortographic contrast media II Nephrotoxicity Surgery 47 (1960) 260

KILLMAN S A, GJORUP S and THAYSEN J H Fatal acute renal failure following intravenous pyelography in a patient with multiple myeloma Acta med scand 158 (1957) 43

LINDGREN P Renal circulatory insufficiency after renal angiography Acta radiol 56 (1961) 423

MCCHESNEY E W and HOPPE J O Studies of the tissue distribution and excretion of sodium diatrizoate in laboratory animals Amer J Roentgenol 78 (1957) 137

MYHRE J R BRODWALL E K and KNUTSEN S B Acute renal failure following intravenous pyelography in cases of myelomatosis Acta med scand 156 (1956) 263

OLSSON O Renal radiography *In* Diseases of the kidney Little Brown & Co Boston 1963

PENDERGRASS E P, CHAMBERLIN G W GODFREY E W and BURDICK E D Survey of deaths and unfavourable sequelae following administration of contrast media Amer J Roentgenol 48 (1942) 741

— HODES P J, TONDREAU R L POWELL C C and BURDICK E D Further considerations of deaths and unfavourable sequelae following administration of contrast media in urography in United States Amer J Roentgenol 74 (1955) 262

SCHWARTZ W B HURWIT A and ETTINGER A Intravenous urography in the patient with renal insufficiency New Engl J Med 269 (1963) 277

STOKES J M and BERNARD H R Nephrotoxicity of iodinated contrast media Quantitative effects of high concentration upon glomerular and tubular functions Ann Surg 153 (1961) 299

VIX V A Intravenous pyelography in multiple myeloma Radiology 87 (1966) 896

DE WARDENER H E The Kidney An outline of normal and abnormal structure and function Churchill London 1958

WOODRUFF M W and MALVIN R L Localization of renal contrast media excretion by stop flow analysis J Urol 84 (1960) 677

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VALUE OF AMNIOGRAPHY IN DETERMINING FETAL VIABILITY

by

H SPINDOLA FRANCO J CEBALLOS LABAT and H A CISNEROS

The early diagnosis of fetal viability is a common clinical problem and accuracy is obtained only in about 50 per cent of cases (WALDMAN et coll 1965) The obstetrician may be unable to establish the diagnosis clinically because of (1) the obesity of the mother (2) the presence of hydramnios with poor transmission of the fetal heart sounds and (3) the diminution of the fetal heart sounds *per se* Changes in the conventional film will be evident only after sufficient time has elapsed for signs of maceration and loss of muscular tone to appear

Roentgenologic criteria of fetal death in the ordinary film According to HOLM 1957) the radiologic signs of intrauterine fetal death may be divided into three groups All of them represent maceration phenomena and loss of muscular tone so that they generally occur from 5 to 8 days after fetal death They have however sometimes been reported on the second or third day (STEWART 1961, ZUPPINGER)

Group I consists in the evaluation of fetal life Demonstration of fetal growth requires repeated radiologic examinations at intervals of several weeks The pres

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ence or absence of fetal movements is studied by serial films of the mother in the same position One film may also be obtained with long exposure, blurring or double exposure of a fetal part will suggest viability although their absence will not necessarily indicate that the fetus is dead Amniography should also be included in this group since it is based on the fact that a live fetus ingests the contrast medium that has been introduced into the amniotic cavity

Group II encompasses the signs of fetal maceration According to ZOLLINGER radiologic evidence of maceration may be detected within 4 to 7 days, but in the majority of cases does not appear until 2 to 3 weeks after fetal death According to NEUWEILER, these maceration signs may be divided into two groups, i e those that affect the cranium and those that affect the trunk The best known of the former is SPALDING'S sign (1922), which consists of overriding of the bones of the calvarium However, overlapping of the bones at the sutures may also be evident in labour with or without rupture of the membranes and loss of amniotic fluid BILLING (1941) demonstrated that even without these conditions the sign may appear in live fetuses, when there is displacement without overriding and the direction of the roentgen beam is oblique in relation to the suture in question SPALDING'S sign must therefore be evaluated with caution Cranial asymmetry flattening of the cranial convexity and non union of the cranial bones due to enlargement of the fetal head may also lead to errors DEUEL described a zone of brightness around the head, resembling a halo this sign is rare

Evidence of maceration of the trunk may consist in exaggeration of the curvature of the fetal vertebral column, causing the fetus to be turned upon itself in the shape of a ball (HARTLEY 1939) Marked lordosis of the spine and hyperextension of the fetal head may in extreme cases attain 180 degrees TAGER (1952) gave great importance to changes in position of the fetus when films of the mother taken decubitus and standing displayed collapse of the fetus

Group III consists of cases with intravascular gas in the fetus this being the only pathognomonic sign of fetal death in the conventional film The mechanism of the gas formation is unknown Several theories have been advanced (ROBERT 1944, DAVIDSON 1949 SAMUEL & GUNN 1955, ELLENBOGEN et coll 1956, STEWART 1961) but none appears satisfactory The sign was initially described by ROBERTS and DAVIDSON later published two further cases TAGER (1952) KETTUNEN (1952) and HOLM (1954) have each added one case, CRICK & SIMS (1953) seven cases SAMUEL & GUNN fifteen cases and MARGOLIS & JONES (1954) two cases

The amniographic method and indications for its use Amniography consists in the introduction into the amniotic fluid of a suitable contrast medium to outline the uterine cavity and the fetus and enable a study of certain feto maternal

physiologic aspects MENEES et coll (1930) and CAMPBELL et coll (1932) described the method for determination of the position of the placenta in the last weeks of pregnancy KERR & McKAY (1933) and BURKE (1935) used it only to a limited extent because the medium employed was too irritant and on occasion produced premature labour The advent of non irritating contrast media has given the procedure new adherents and attention has now been drawn to its safety as well as its value in obstetrics (McLAIN Jr 1964)

As to the indications for its use the following may be mentioned

1 For determination of the placental implantation site amniography offers valuable information which cannot be obtained by clinical or by other radiographic means Amniography always reveals the placenta as a filling defect in the cavity of the amniotic sac

2 In the presence of uterine tumour and pregnancy amniography locates and differentiates the neoplasm from the placenta, it also indicates their sizes

3 Amniograms may disclose uterine anomalies responsible for abnormal presentations of the fetus

4 Fetal anomalies such as meningoceles and myeloceles may be diagnosed Amniography is indicated in hydramnios because of an association with a high incidence of fetal anomalies

5 GRANJON (1948) CETRONI & AZZARITI (1934), ALBANO & GALLINA (1934) and KERR & McKAY (1933) stated that they have sometimes been able to determine the sex of the fetus and on occasions have identified the umbilical cord SAVIGNAC (1953) has never been able to demonstrate the cord by amniography It is well outlined in one case of the present material (Fig 6)

6 In multiple pregnancy amniography will determine whether it is uni or bi amniotic and whether the placentation is single or double (PORTES et coll 1948 GRANJON et coll 1949)

7 A viable fetus ingests the contrast medium contained in the amniotic fluid which is easily identified in the fetal gastrointestinal tract The presence of the medium in the tract thus indicates that the fetus is alive its absence means that the fetus is dead Amniography is thus of great value in the diagnosis of fetal death when this cannot be determined by other means, this was first mentioned by EHRHARDT (1937) and later by SAVIGNAC (1953) and WALDMAN et coll (1965)

Material The series consists of 25 amniographic studies the ages of the subjects varying from 17 to 38 years and the stage of pregnancy from 22 to 40 weeks Twenty-one cases were admitted with the initial clinical diagnosis of probable fetal death two with polyhydramnios and possible fetal death, one with cephalopelvic di proportion and fetal death and one case with polyhydramnios with or

ence or absence of fetal movements is studied by serial films of the mother in the same position One film may also be obtained with long exposure, blurring or double exposure of a fetal part will suggest viability although their absence will not necessarily indicate that the fetus is dead Amniography should also be included in this group since it is based on the fact that a live fetus ingests the contrast medium that has been introduced into the amniotic cavity

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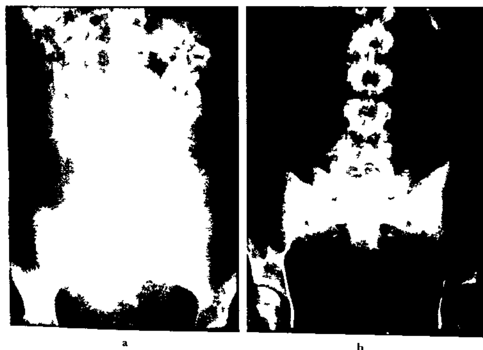


Fig 2 a) 1 hour film The amniotic cavity is well filled with contrast medium which was eliminated by the maternal renal tract No medium in the fetal gastrointestinal tract b) 6-hour film The amniotic cavity is faintly outlined contrast medium in the maternal urinary bladder (Rapid elimination of the contrast medium probably precluded its swallowing by the fetus A live infant was delivered 2 days later Erroneous diagnosis of fetal death 26 weeks gestation)

The amniographic diagnosis was confirmed clinically in 24 cases (96 %) One case was erroneously diagnosed as fetal death (Fig 2 Table 1) The reasons for this error are discussed in detail later

In ten cases (89 %) the nature of the amniotic fluid suggested the diagnosis of fetal death (Table 1) Only in one case was it normal In those cases in which the amniographic diagnosis was that of a live fetus the characteristics of the amniotic fluid were normal except in one case in which it was whitish in colour and viscid (Table 2 Case 19)

Of the evidences of fetal death in the conventional film Hartley s and Spalding s signs were most frequently observed and these nearly always appeared together (Table 1) Tager s sign Deuel s halo and the presence of intravascular gas were not recorded In those cases in which a diagnosis of fetal death was made labour was initiated within 72 hours after the amniographic procedure

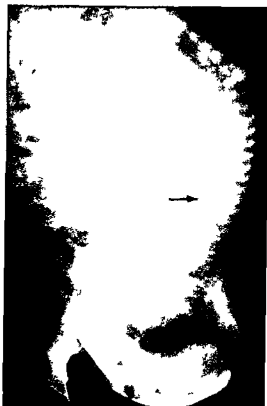


Fig 1 Fetal distress The amniogram one hour *after injection shows contrast medium in the* esophagus (arrow) Overriding of the calvarium (On the repeat film there was no further advance of the contrast medium)

withdrawn, but a free flow of fluid through the needle before the medium is introduced is essential The amount of contrast medium is between 30 and 40 ml depending on the estimated total quantity of amniotic fluid present

7 The contrast medium must be warmed to body temperature to lower its viscosity and to allow better diffusion

8 Note is taken of the characteristics of the amniotic fluid

9 Films 3 hour a p and lateral films in decubitus are obtained If no medium appears *in the fetal gastrointestinal tract, the series is repeated at 6 hours with* occasionally a late film at 24 hours

Results

The clinical data, amniographic findings and clinical amniographic correlation are collected in Tables 1 and 2

The viability of the fetus was assessed by the presence or absence of contrast medium in the fetal gastrointestinal tract The location and time of its appearance are indicated in Table 2 The contrast medium was observed in 13 cases (52 %) (Figs 1, 3 and 5) and was not visible in 11 cases (44 %) (Figs 2a, 2b and 6) The remaining case was one of a retained placenta (Table 1, Fig 4)



Fig 2 a) 1 hour film The amniotic cavity is well filled with contrast medium which was eliminated by the maternal renal tract No medium in the fetal gastrointestinal tract b) 6-hour film The amniotic cavity is faintly outlined contrast medium in the maternal urinary bladder (Rapid elimination of the contrast medium probably precluded its swallowing by the fetus A live infant was delivered 2 days later Erroneous diagnosis of fetal death 26 weeks gestation)

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Fig 3 A 37 week pregnancy with clinical diagnosis of polyhydramnios with or without twin pregnancy Amniogram obtained at 4 hours *reveals contrast medium in segmental* distribution in the fetal small intestine (Amniographic diagnosis of single live fetus pregnancy progressed to full term)

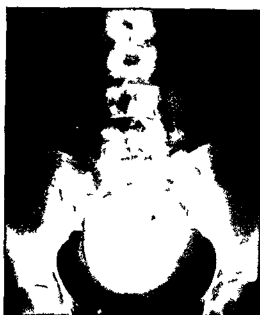


Fig 4 Amniogram in a case of possible fetal death reveals a retained placenta (Fetal parts had been seen the week before *in the conventional roentgenogram the fetus* had been expelled in the interim)

(Table 1) However in the majority of cases (8 cases) it was started within 48 hours On the other hand, in cases in which the fetus was considered to be alive labour was not initiated after the procedure

The contrast medium was excreted by the maternal kidneys with the maternal urinary bladder filled at 3 hours In only one case was the elimination rapid (Case 3, Fig 2) The fetal urinary tract was never observed

In the cases having a live fetus (Table 2), the velocity of the contrast medium passing through the fetal gastrointestinal tract varied slightly according to age The medium usually appeared in the small intestine at about 3 hours after injection In one case it was obviously delayed (Table 2 Case 20) This was the youngest fetus in which the procedure was carried out In Case 13 (Table 2, Fig 1) the progress of the contrast medium was markedly delayed it failed to advance beyond the esophagus This suggested severe fetal distress, which was confirmed 24 hours later when a dead product was delivered

In Case 10 with the clinical diagnosis of probable fetal death (Table 1) the conventional film displayed fetal parts, but amniography performed one week later revealed only a retained placenta (Fig 4) The fetus had been expelled in the interim



Fig 5 A 26 week pregnancy in which fetal death was likely The amniogram shows contrast medium in the small and large intestine with nodular and columnar appearance suggesting a live fetus (Pregnancy progressed to full term)



Fig 6 Absence of contrast medium in the gastrointestinal tract in the 3 hour amniogram indicates fetal death The umbilical cord (arrow) as well as the fetal soft parts are visible (Spontaneous delivery of a dead product 72 hours after amniography)

No more than four exposures were obtained in each case No allergic reactions due to the contrast medium were recorded The medium never appeared in the fetal respiratory system No injuries to the fetus attributable to the puncture were observed on examination after delivery

Comments

Amniography is a simple and innocuous procedure that permits the study of certain maternal fetal physiologic aspects as well as the conformation of the uterine fetal placental relationship The aims of the method are not only diagnostic but also therapeutic in the cases in which the diagnosis of fetal death was made labour began within 72 hours of the amniographic study On the other hand the pregnancies continued their normal course in the cases with an amniographic diagnosis of a live fetus It is possible in cases of polyhydramnios to carry

out amniocentesis, and thereby allow the pregnancy to progress, since premature labour is precluded by the decrease in the uterine distension No harmful effects have arisen either to the fetus or mother after amniocentesis (LILEY 1965), although the possibility of producing visceral hemorrhages exists due to a decompression effect Because of this not more than 250 ml of amniotic fluid should be withdrawn at a time PORTES, GRANJON & HASSANT (1947) have withdrawn from 200 to 300 ml weekly without apparent harm

The appearance of the contrast medium in the fetal gastrointestinal tract is columnar in the esophagus and large intestine and nodular in the small bowel In the very immature fetus the medium appears to be viscid (Figs 1, 3 and 5) Haustral markings in the large intestine may be identified (Fig 5)

Motility and gastrointestinal activity increase as the pregnancy advances (MCLAIN Jr 1963, WALDMAN et coll 1965) BECKER et coll (1940) have demonstrated the physiologic aspects of fetal swallowing and gastrointestinal activity The more immature the fetus, the slower the gastrointestinal activity It is possible in complicated pregnancies with pathologic disorders to determine the degree of fetal distress by assessing the rapidity or sluggishness of the gastrointestinal activity

Diminution in the rate of fetal swallowing occurs in diabetic cases, as well as in those of polyhydramnios, and consequently the gastrointestinal activity is delayed This may be an important factor in the development of polyhydramnios These observations suggest that the fetal gastrointestinal tract may play an important part in the regulation of the amniotic fluid

MCLAIN (1963) observed that fetal gastrointestinal activity is augmented in complicated pregnancies by Rh iso immunization, chronic nephropathy and toxemia, he suggested that this might be a sign of early fetal distress He found diminution of the activity, which he regarded as a manifestation of late fetal distress in the hydropic fetus as well as in premature separation of the placenta

One case is included in which a diagnosis of fetal death was made (Case 3, Table 1, Fig 2) in a 26 week pregnancy in which the fetus proved to be alive Amniograms obtained at 1, 3 and 6 hours revealed no evidence of contrast medium in the fetal gastrointestinal tract and suggested the diagnosis Excretion of the medium by the maternal kidneys was observed in the 1 hour amniogram (maternal urography), and persisted in the films that followed The density of the contrast medium in the amniotic cavity decreased simultaneously until only traces of the medium were left We believe that the phenomenon was due to an increase in the permeability of the amniotic membranes which may have lessened the fetal swallowing MCLAIN examined these amniograms and expressed the opinion that some medium lay in the fetal gastrointestinal tract he could however, not explain its rapid elimination by the maternal kidneys On the other hand, JA

COBSON suggested that the medium had been injected either into the uterine wall or into the umbilical cord However there was a free flow of amniotic fluid of a normal nature through the needle to the syringe at the time of the examination The increase in the permeability of the membranes may possibly offer a valid explanation

Acknowledgement

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SUMMARY

Amniography proved to be a useful simple and harmless procedure in determining fetal viability in a series of 25 cases No untoward maternal or fetal complications were encountered and accuracy was obtained in all but one of the cases

ZUSAMMENFASSUNG

Amniographie erwies sich als eine gute einfache und harmlose Methode um die Lebenfähigkeit des Fotus in 25 Fällen zu bestimmen Weder materne noch fetale Komplikationen wurden beobachtet und die Diagnose war mit Ausnahme von einem Fall korrekt

RÉSUMÉ

L'amniographie s'est revelée un moyen utile simple et sans danger pour determiner la viabilité foetale sur une serie de 25 cas Il n'y a pas eu de complications maternelles ni foetales, et le diagnostic a eté exact dans tous les cas sauf un

REFERENCES

ALBANO und GALLINA Technik Biologie und Resultate der Amniographie Abst Zbl. Gynak. 58 (1934) 1134

BECKER R. F WINDLE W F BARTH E E and SCHULZ M D Fetal swallowing gastrointestinal activity and defecation in amnio An experimental roentgenological study in the guinea pig Surg Gynec Obstet 70 (1940) 603

BILLING L. Über die Bedeutung des rontgenographischen Übereinanderschiebens der Schadelknochen des Fotus Acta radiol 22 (1941) 277

BURKE F J Amniography J Obstet Gynaec Brit Emp 42 (1935) 1096

CAMPBELL A M MILLER J D MENEES T O and HOLLY L E Diagnostic value of radiopaque contrast media in gynecology and obstetrics Amer J Obstet Gynec 24 (1932) 542

CETRONI M und AZZARITI M Über die Amniographie Abst Zbl Gynak 58 (1934) 1132

CRICK A F and SCHUS F H Cited by HOLM (1957)

DAVIDSON C. A Roentgen demonstration of fetal death (gas within the fetus) and uterine rupture Amer J Roentgenol 62 (1949) 837

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Motility and gastrointestinal activity increase as the pregnancy advances (McLAIN Jr 1963, WALDMAN et coll 1965) BECKER et coll (1940) have demonstrated the physiologic aspects of fetal swallowing and gastrointestinal activity The more immature the fetus, the slower the gastrointestinal activity It is possible in complicated pregnancies with pathologic disorders to determine the degree of fetal distress by assessing the rapidity or sluggishness of the gastrointestinal activity

Diminution in the rate of fetal swallowing occurs in diabetic cases as well as in those of polyhydramnios, and consequently the gastrointestinal activity is delayed This may be an important factor in the development of polyhydramnios These observations suggest that the fetal gastrointestinal tract may play an important part in the regulation of the amniotic fluid

McLAIN (1963) observed that fetal gastrointestinal activity is augmented in complicated pregnancies by Rh iso immunization chronic nephropathy and toxemia, he suggested that this might be a sign of early fetal distress He found diminution of the activity, which he regarded as a manifestation of late fetal distress in the hydropic fetus as well as in premature separation of the placenta

One case is included in which a diagnosis of fetal death was made (Case 3, Table 1, Fig 2) in a 26 week pregnancy in which the fetus proved to be alive Amniograms obtained at 1, 3 and 6 hours revealed no evidence of contrast medium in the fetal gastrointestinal tract and suggested the diagnosis Excretion of the medium by the maternal kidneys was observed in the 1 hour amniogram (maternal urography), and persisted in the films that followed The density of the contrast medium in the amniotic cavity decreased simultaneously until only traces of the medium were left We believe that the phenomenon was due to an increase in the permeability of the amniotic membranes, which may have lessened the fetal swallowing McLAIN examined these amniograms and expressed the opinion that some medium lay in the fetal gastrointestinal tract he could however, not explain its rapid elimination by the maternal kidneys On the other hand, JA

ROBSON suggested that the medium had been injected either into the uterine wall or into the umbilical cord However there was a free flow of amniotic fluid of a normal nature through the needle to the syringe at the time of the examination The increase in the permeability of the membranes may possibly offer a valid explanation

Acknowledgement

The authors take this opportunity of thanking Prof Milton Elkin (Albert Einstein College of Medicine New York) and Prof Harold C Jacobson (Montefiore hospital New York) for their advice and encouragement

SUMMARY

Amniography proved to be a useful simple and harmless procedure in determining fetal viability in a series of 25 cases No untoward maternal or fetal complications were encountered and accuracy was obtained in all but one of the cases

ZUSAMMENFASSUNG

Amniographie erwies sich als eine gute einfache und harmlose Methode um die Lebensfähigkeit des Fötus in 25 Fällen zu bestimmen Weder materne noch fetale Komplikationen wurden beobachtet und die Diagnose war mit Ausnahme von einem Fall korrekt

RÉSUMÉ

L amniographie s est revelee un moyen utile simple et sans danger pour determiner la viabilite foetale sur une serie de 25 cas Il n y a pas eu de complications maternelles ni foetales et le diagnostic a ete exact dans tous les cas sauf un

REFERENCES

ALBANO und GALLINA Technik Biologie und Resultate der Amniographie Abst Zbl Gynak 58 (1934) 1134

BECKER R F WINDLE W F BARTH E F and SCHULZ M D Fetal swallowing gastrointestinal activity and defecation in amnio An experimental roentgenological study in the guinea pig Surg Gynec Obstet 70 (1940) 603

BILLING L Über die Bedeutung des röntgenographischen Übereinanderschiebens der Schädelknochen des Fötus Acta radiol. 22 (1941) 277

BURKE F J Amniography J Obstet Gynaec Brit Emp 42 (1935) 1096

CAMPBELL A M MILLER J D MENEES T O and HOLLY L E Diagnostic value of radiopaque contrast media in gynecology and obstetrics Amer J Obstet Gynec 24 (1932) 542

CETRONI M und AZZARITI M Über die Amniographie Abst Zbl Gynak 58 (1934) 113?

CRICK A F and SIMS F H Cited by HOLM (1957)

DAVIDSON C N Roentgen demonstration of fetal death (gas within the fetus) and uterine rupture Amer J Roentgenol 62 (1949) 837

DEUEL H Zur Rontgendiagnose des intrauterinen Fruchttodes Schweiz med Wschr 77 (1947) 1003
EHRHARDT K Der trinkende Fotus Eine rontgenologische Studie Münch med Wschr 84 (1937), 1699
ELLINBOGEN L S BAYER H and GOTTLIEB M Roentgen demonstration of gas in the fetal circulatory system, a valuable sign of fetal death Radiology 67 (1956), 410
GRANJON A A propos du diagnostic du sexe pendant la grossesse Presse méd 56 (1948) 688
— BOMMELAER M et BEAU A M Physiopathologie du foetus in utero Données radiologiques Presse méd 57 (1949) 1239
HARTLEY J B Radiology in pregnancy Brit J Radiol 12 (1939) 113
HOLM O I Free gas in the fetal vessels as a roentgenologic sign of intrauterine fetal death Acta radiol 42 (1954) 116
— The roentgenological signs of intrauterine fetal death Acta obstet gynec scand 36 (1957) 58
— Deuel s halo sign Amer J Roentgenol 80 (1958) 681
JACOBSON H G Personal communication
KERR J M M and MCKAY W G The diagnosis of placenta previa with special reference to employment of X rays for this purpose Trans Edinb obstet Soc 40 (1933) 21
KETTUNEN K Fetal death diagnosed roentgenographically by the presence of gas in the fetal circulatory system Acta radiol 37 (1952) 81
LILLY A W Amniocentesis New Engl J Med 272 (1965) 731
MARGOLIS A J and JONES M D Gas within circulation of dead fetus in utero Report of two cases Obstet and Gynec 3 (1954) 631
MCLAIN JR C R Amniography a versatile diagnostic procedure in obstetrics Obstet and Gynec 23 (1964) 45
— Amniography studies of the gastrointestinal motility of the human fetus Amer J Obstet Gynec 86 (1963) 1079
— Personal communication
MENEES O I MILLER J D and HOLLY L E Amniography A preliminary report Amer J Roentgenol 24 (1930) 363
NEUWEILER B Cited by STEWART (1961) and by HOLM (1954)
PORTES L GRANJON A et MELLE HASSANT Les ponctions amniotiques transcutanées dans le traitement de l hydramnios aigu Gynéc et Obstét 46 (1947) 475
— LEFEBVRE J et GRANJON A L amniographie Gynéc et Obstét 47 (1948) 378
ROBERTS J B Gas in the fetal circulatory system as a sign of intrauterine fetal death Amer J Roentgenol 51 (1944) 631
SAMUEL E and GUNN K Gas embolus as a sign of fetal death Amer J Roentgenol 73 (1955) 974
SAVIGNAC L M Roentgen amniography A valuable and safe aid to obstetrical diagnosis Radiology 60 (1953) 545
SPALDING A B A pathognomonic sign of intrauterine death Surg Gynec Obstet 34 (1922) 754
STEWART A M The study of free gas in the foetus as a sign of intrauterine death Brit J Radiol 34 (1961) 187
TAGER S N A new roentgen sign of fetal death Amer J Roentgenol 67 (1952) 106
WALDMAN I BERLIN L and MCLAIN JR C R Amniography in the diagnosis of fetal death Radiology 84 (1965) 1066
ZUPPINGER A Cited by HOLM (1957)

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ANEURYSM OF THE SPLENIC ARTERY

by

ERIK BOIJSEN and H O EFSING

Until some 20 years ago the roentgen diagnosis of aneurysm of the splenic artery was based on the demonstration of a characteristic calcification in the left hypochondrium The first aneurysms of the splenic artery diagnosed by aortography were described by WAGNER (1946) Since then many calcified aneurysms detected by conventional roentgenography have been verified by aortography (SMITH et coll 1952 and others) Uncalcified aneurysms have also been diagnosed angiographically in recent years usually in association with the investigation of acute gastrointestinal haemorrhage or diffuse abdominal pain (SPITTEL et coll 1961 ROSCH & BRET 1962 ROSCH 1967 BAUM et coll 1965, OTTE & REUTER 1966 KUPIC et coll 1967 SMITH & HILL 1967)

BOIJSEN & EFSING (1967) reported intrasplenic aneurysms following puncture for splenoportal phlebography in patients with portal hypertension Their series included several patients with extrasplenic aneurysms of the splenic artery Splenomegaly especially when caused by portal hypertension is sometimes associated with extrasplenic aneurysms of the splenic artery (OWENS & COFFEY 1953 SHEPS et coll 1958) The frequency of aneurysms in patients with portal hypertension is unknown

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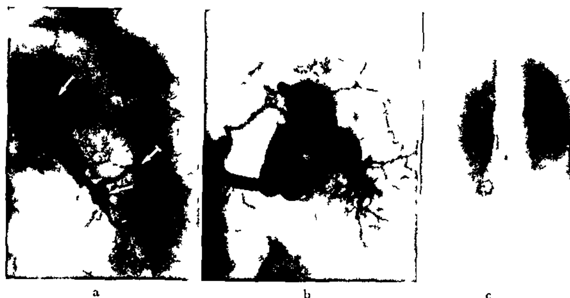


Fig 1 Celiac angiography for cirrhosis of the liver and portal hypertension in a woman aged 56 a) Frontal b) left posterior oblique projection and c) operation specimen There were 3 aneurysms (—→) of respectively 25 mm 10 mm and 6 mm diameter in the hilum of the spleen and also a 5 mm×6 mm intrasplenic aneurysm (→→) (Calcifications were observed in the large and medium sized aneurysms in the conventional films)

Since now celiac angiography has provided a new possibility of demonstrating aneurysms of the splenic artery it was considered important to assess the frequency and sites of extrasplenic aneurysms of this artery in patients with hepatic cirrhosis and portal hypertension, especially since uncalcified aneurysms have a fairly strong tendency to rupture (von RONNEN 1953 and others)

We have reviewed the films of a consecutive series of patients who had been examined with celiac angiography for different reasons, and the findings were compared with those obtained in a corresponding series of patients with hepatic cirrhosis and portal hypertension, as well as with those obtained in patients who had splenic or portal hypertension secondary to some other condition

Material and Methods Group I consisted of 192 patients (103 males 89 females), or all the celiac angiographic examinations performed in 1966 in which the entire extrasplenic part of the splenic artery could be evaluated, usually in two projections

Group II consisted of 115 patients (59 males, 56 females) examined in the period 1957—1966 by celiac angiography for primary or secondary affection of the portal system Ninety one of these patients had hepatic cirrhosis with or without portal hypertension while twenty four had lesions of the portal system

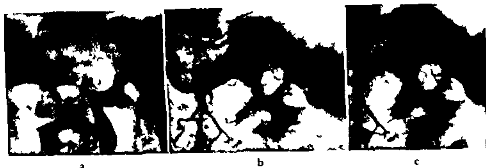


Fig 2 Chronic pancreatitis and portal hypertension in a man aged 51 with gastric resection for recurrent gastro intestinal bleeding pain and increased bilirubin a) Splenoportal phlebography Marked stenosis of the portal vein and deformation of the splenic vein b) and c) Celiac angiography Spleen of normal size (14 cm) splenic artery of normal width and only slightly tortuous. At the origin of the pancreatic magna artery a 16 mm aneurysm of the splenic artery penetrates into the pancreas deforming the splenic vein (Chronic pancreatitis and a wide pancreatic duct were revealed at operation the aneurysm was thought to have penetrated the duct and caused the bleeding)

without co-existing cirrhosis Again only those patients in whom the entire extra splenic part of the artery could be judged were included

The conventional roentgenograms of the abdomen were re-examined for calcifications in those patients who proved to have aneurysms

Results

Group I Celiac angiography had been performed for various reasons though usually because of diffuse abdominal pain It was never done because an aneurysm of the splenic artery was considered likely Nine patients had aneurysms of the splenic artery or one of its branches in the hilum of the spleen Re examination in one of the patients revealed two faint aneurysmal calcifications 25 mm and 10 mm in diameter (Fig 1) Six of the nine patients had histologically verified hepatic cirrhosis of these six patients three had portal hypertension and in the other three end to-side portacaval anastomosis had previously been established because of portal hypertension

The portal system was involved in two further patients One had portal hypertension secondary to chronic pancreatitis with stenosis of the portal vein (Fig 2) and the other had massive richly vascularized hepatic metastases (Fig 3) The contrast medium was shunted to the portal vein with reversal of the flow in the portal system venous collaterals and slight enlargement of the spleen (17 cm) were noted as signs of moderate portal hypertension



Fig 3 Hepatic metastases from mammary carcinoma in a woman aged 52 Celiac angiography revealed vascularized metastases of the liver and a 5 mm × 7 mm aneurysm (→) in the main stem of the moderately tortuous splenic artery the spleen was slightly enlarged (17 cm) The contrast medium flowed to the intrahepatic portal vein via the metastases reverse flow and portal hypertension *with retrograde filling of the* inferior mesenteric vein

Only in one patient in this group with an aneurysm of the extrasplenic part of the splenic artery, was the portal system apparently unaffected A 39 year old woman had been examined because of an expanding process in the inferior mediastinum, with displacement of the lower part of the oesophagus The tumour proved to be a bronchogenic cyst At celiac angiography (Fig 4) the hepatic and splenic arteries were wide and tortuous and the celiac artery was markedly tenosed Atheromatosis was assumed but not confirmed

Thus, of the patients examined in 1966, the portal system had been affected in some way in thirty four including eight who had 1 to 3 aneurysms each Of *the remaining 158 patients in this consecutive series an aneurysm was present in* only one

Group II This group consisted of the above mentioned 34 patients examined in 1966, and of 81 further patients with splenic or portal vein disease Seventeen (4 males and 13 females) had one or more aneurysms of the extrasplenic part of the plenic artery Multiple aneurysms were found in three patients, namely 2 in two patients and 3 in one patient

The extrasplenic aneurysms varied between 5 mm and 25 mm (mean 12 mm) In one patient, no local bulging was seen but there were slight irregular widening and a dissection along a stretch of about 2 cm of the splenic artery (Fig 5)

Six of the twenty one aneurysms were situated in the trunk of the splenic artery, the others lying in branches in or near the splenic hilum Of those situated in the trunk, four were located at the origin of an arterial branch running to the



a b

Fig 4 Bronchogenic cyst of inferior mediastinum in a woman aged 39 a) Preoperative celiac angiography revealed a 7 mm × 9 mm aneurysm (→) in the middle segment of a markedly tortuous splenic artery atheromatous changes of all branches of the celiac axis artery which was stenosed at its origin b) Superior mesenteric angiography revealed collateral circulation to the celiac system

pancreas or to one of the poles of the spleen The hilar aneurysms were usually situated at bifurcations of the branches of the splenic artery

The width of the splenic artery in the group with aneurysms was approximately the same as in comparative groups without aneurysms The tortuosity of the splenic artery in cases of aneurysms was approximately the same as in the rest of the material

The length of the spleen was measured in the capillary phase of the angiograms and the spleen was said to be enlarged when it was 15 cm or longer (for definition see Rosch 1967) Fourteen of the 17 patients with aneurysms had an enlarged spleen The mean value for the entire group with aneurysms was 18 2 cm The ages of the patients with involvement of the portal system but without aneurysms ranged from 6 to 76 (mean 55 years) The corresponding figures for the seventeen patiens (4 males 13 females) with aneurysms were 17 and 66 (mean 48 years)

Extrasplenic aneurysms were most common in patients with hepatic cirrhosis and portal hypertension (7 out of 42 patients) in those in whom portal hypertension had been treated surgically with portacaval anastomosis (5 out of 23) and in those with spontaneous thrombosis of the portal vein (1 out of 3 patients) These groups comprised in all 68 patients, and in these the splenic artery was



Fig. 3. Hepatic metastases from mammary carcinoma in a woman aged 52. Celiac angiography revealed vascularized metastases of the liver and a 5 mm × 7 mm aneurysm (→) in the main stem of the moderately tortuous splenic artery; the spleen was slightly enlarged (17 cm). The contrast medium flowed to the intrahepatic portal vein via the metastases: reverse flow and portal hypertension with retrograde filling of the inferior mesenteric vein.

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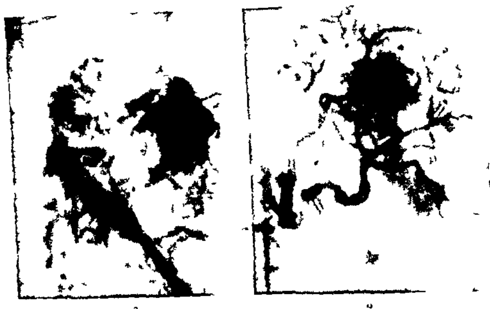


Fig 6 Carcinoma of body and tail of the pancreas in a woman aged 51 a) Splenoportal phlebography Occlusion of the splenic vein and marked venous collateral circulation b) Celiac angiography Stenosis of the first segment of the splenic artery and a 8 mm × 10 mm aneurysm distally (⟶) A second aneurysm (⟶) at the point in the spleen to which the catheter had been advanced at splenoportal phlebography

than cirrhosis of the liver or spontaneous thrombosis extrasplenic aneurysms of the splenic artery were present in four including one patient who had an intrasplenic aneurysm as well In the majority of these patients the portal hypertension was usually secondary to pancreatitis (9) or carcinoma of the pancreas (7) Two patients with richly vascularized hepatic metastases had reverse flow through the portal vein and signs of portal hypertension One of them had a 7 mm × 7 mm aneurysm in the intermediate part of the main trunk of the splenic artery

In patients with carcinoma of the tail or body of the pancreas the splenic artery was often stenosed and the splenic vein occluded with consequent splenic hypertension The spleen was of normal size or only slightly enlarged despite a well developed collateral circulation Only one out of the seven patients with carcinoma of this part of the pancreas had an extrasplenic aneurysm This measured 8 mm × 10 mm and was situated immediately distal to the stricture it was conceived as a jet aneurysm The patient also had an intrasplenic aneu



Fig 5 Chronic pancreatitis and pseudocyst formation close to the tail of the pancreas in a man aged 41 slight portal hypertension due to compression of the splenic vein Celiac angiography (a) and combined angiography (b) performed in a p and right oblique projections Long (about 2 cm) irregular widening of first segment of splenic artery subintimal leakage (⟶) of contrast medium There is a second aneurysmal widening of the first segment of the gastroduodenal artery

more tortuous and wider, and the spleen was larger, than in the remaining patients with portal involvement Extrasplenic aneurysms were demonstrated in thirteen (19 %) of the 68 patients Intrasplenic aneurysms were present in the same groups of patients of the previously mentioned 68 patients intrasplenic aneurysms were observed in fourteen, and in eight of these, extrasplenic aneurysms of the splenic artery were also present

The total number of patients with extrasplenic aneurysms might have been higher for in some instances the arteries were so tortuous that aneurysms might have been missed despite more than one projection Moreover, the changes were accepted as aneurysms only when the diagnosis was definite

It is noteworthy that neither extrasplenic nor intrasplenic aneurysms were observed in 12 patients with hepatic cirrhosis without portal hypertension nor in 14 with primary carcinoma of the liver which in ten of the patients was associated with portal hypertension

Of 21 patients with portal hypertension secondary to some condition other

two to three times more common in women while aneurysms of other arteries or of the aorta occur *four to five times more often* in men (SHERLOCK & LEARMONTH 1942, OWENS & COFFEY 1953, SPITTEL et coll 1961 YANG et coll 1963) Among older patients the incidence is roughly equal in both sexes (FELDMAN 1955, LENNIE & SHEEHAN 1942 SHERWIN & GORDIMER 1950) The same remarkable distribution was even more striking in the present series only four of the 18 patients being men, despite a slight preponderance of males in the series examined by celiac angiography

The frequency of calcifications in aneurysms of the splenic artery varies widely from one series to another depending on selection factors Thus SPITTEL et coll (1961) reported that seventeen of nineteen patients with aneurysms examined clinically had calcifications and BYERS & BUXTON (1967) stated that the diagnosis was made almost entirely on the basis of calcifications in six out of their seven patients OWENS & COFFEY in a collective review of aneurysms of the splenic artery found that roentgenography or fluoroscopy gave valuable diagnostic information in 19 of 131 cases (15 %) and demonstrated calcifications as well as a pulsatile mass of the stomach Since 46 % of the cases examined had a ruptured aneurysm of the splenic artery this reviewed material was also selected and therefore does not reflect the true frequency of calcifications The frequency of calcifications in aneurysms of the splenic artery is low in patients with portal hypertension as demonstrated in the present material Only in two of the twenty-one aneurysms with coexisting portal hypertension were any calcifications observed The mean diameter of the aneurysms in the compilation of OWEN & COFFEY was 31 mm, while in the present material it was 12 mm and signs of rupture were seen in only one patient in whom the aneurysm was 16 mm in diameter This therefore suggests that calcifications appear in a late stage of development of an aneurysm The low frequency of calcifications in aneurysms in this material may probably be explained by the assumption that the aneurysms were discovered early with angiography

Calcifications formerly played an important role in the diagnosis and it was eriously questioned whether calcified aneurysms really could rupture (von RONNEN 1953 CULVER & PIRSON 1957 MOORE & LEWIS 1961) That rupture of a calcified aneurysm may occur has however, been unequivocally demonstrated (TAGART 1952, SPITTEL et coll 1961) The chances of a ruptured aneurysm being calcified are small simply because so few aneurysms are calcified

The frequency of rupture of aneurysms of the splenic artery has been assessed as 35 % (BERGER et coll 1953) The frequency was 38 % in the 32 cases of aneurysm and portal hypertension collected by OWENS & COFFEY The true risk of rupture is much lower however because in the present material only one patient out of 17 (6 %) with portal hypertension had signs of rupture This is in

rysm, measuring 5 mm×5 mm, as a result of a previous puncture for splenoportal phlebography (Fig 6) Three patients with retroperitoneal sarcoma and occlusion of the splenic vein, as well as involvement of the tail of the pancreas, had no stricture or aneurysm of the splenic artery

In 9 patients with chronic pancreatitis, pseudocysts, or abscess in or adjacent to the tail and body of the pancreas, the splenic vein or portal vein was either deformed or occluded, with consequent portal hypertension or splenic hypertension Two patients had an aneurysm of the trunk of the splenic artery The aneurysm was sacculated in one of these patients, it had penetrated the pancreatic tissue and was surrounded by inflammatory changes This aneurysm caused gastrointestinal haemorrhage, for which the patient had been examined by angiography (see Fig 2) The other patient had a pseudocyst adjacent to the tail of the pancreas and a moderate amount of fatty tissue necrosis as well as portal hypertension A subintimal accumulation of contrast medium suggested dissection of the first part of the splenic artery (Fig 5)

Discussion

Aneurysms of the splenic artery are believed to be comparatively rare, but they are obviously more common than supposed, a large number may remain undetected Ante mortem diagnosis of non calcified aneurysms requires either angiography or operation, and even then the discovery of the lesion is generally incidental

The frequency with which aneurysms of the splenic artery is found at autopsy varies widely SHEPS et coll (1958) gave a frequency of 0 05 % on the basis of the literature but found such aneurysms three times as often in a personal autopsy series FELDMAN (1955) reported a still higher figure, namely 0 8 % and suggested that the low figures of previous investigators were due to incomplete exploration of the splenic artery and its branches at autopsy FERRARI (1938) examined the splenic artery carefully in 143 subjects in ages over 60 and reported small aneurysms in 14 but none in 88 subjects below 60 years of age Opinions thus differ widely on the incidence of aneurysms of the splenic artery — even those based on autopsy studies—and will probably continue to do so until angiography has become a routine method at autopsy The high frequency of aneurysms of the splenic artery in the present consecutive series of celiac angiographies was due entirely to the fact that so many patients with portal hypertension were examined

The remarkable sex distribution of aneurysm of the splenic artery is noteworthy, particularly in patients below 50 years of age It has been described as

portal hypertension in 32 out of 204 patients with aneurysms Further cases have since been reported including a patient who had previously been operated upon and given a portacaval anastomosis (WARD McQUAID 1958) Thus, though *portal hypertension is obviously one of the commoner causes* of aneurysms it is remarkable that so few aneurysms have been described in the literature Since we found aneurysms in 13 out of 68 patients examined angiographically because of *hepatic cirrhosis* with portal hypertension portal hypertension relieved by operation or spontaneous thrombosis of the portal system this suggests that the frequency of aneurysms must be substantially *higher than hitherto supposed*

No aneurysms were present in patients with uncomplicated cirrhosis nor were any aneurysms seen in patients with cirrhosis combined with primary carcinoma of the liver, though portal hypertension was *common The hypertension* was in these patients probably of short duration since it was caused by the tumour compressing or infiltrating the portal vein Aneurysms therefore appear to be *directly related to long* standing *chronic* stasis and subsequent changes in the splenic artery The clear correlations in our series between the width and the tortuosity of the splenic artery and between the size of the spleen and the occurrence of extrasplenic aneurysms of the splenic artery also strongly suggest a relation between the degree and duration of portal stasis and the occurrence of aneurysms Since aneurysms were evident in almost *20 % of* patients with cirrhosis and portal hypertension we believe celiac angiography is always indicated for the contemplated establishment of a shunt Splenectomy and plenorenal *anastomosis would appear more adequate treatments in patients with* a coexisting aneurysm

Chronic pancreatitis has sometimes occurred in patients with aneurysm of the splenic artery (LOWER & FARRELL 1931 HUGHES & JOSHE 1955 MOORE & LEWIS 1961 BAUM et coll 1965) Our series included aneurysms in two out of nine patients with chronic pancreatitis associated with portal hypertension In one of these patients the splenic artery was dissected for a length of about 2 cm SHEPS et coll (1958) found two dissecting aneurysms of the splenic artery one of which had *developed in association with acute haemorrhagic* pancreatitis The cause of aneurysm formation in pancreatitis is obscure but there may be some relationship between arterial lesions and fatty necrosis

It is obvious that celiac angiography *is useful in the diagnosis of aneurysms* of the splenic artery Some authors believe selective angiography of the visceral arteries to be unnecessarily complicated for this diagnosis (SPITTEL et coll 1961 DORMAN & CARNEY 1965) Selective angiography however is necessary for diagnosing intrasplenic aneurysms (BOIJSEN & EFSING) and this in our opinion also applies largely to *extrasplenic aneurysms* because such a diagnosis requires several projections and high quality angiograms

agreement with that (8 2 %) observed by SPITTEL et coll (1961) in a compilation of 61 aneurysms

OWENS & COFFEY reported that two thirds of all aneurysms were situated in the trunk of the splenic artery, the remainder in branches, usually in the hilum outside the spleen In our series only a quarter were situated in the splenic trunk, which corresponds with the observations of FERRARI in an autopsy series with a high incidence of small arteriosclerotic aneurysms The difference may be due to different selection factors The very high frequency of ruptured aneurysms in the series of OWENS & COFFEY suggests that aneurysms of the trunk are prone to rupture, as in the one case of rupture in our series

It would thus appear that aneurysms exceeding about 15 mm in diameter and situated in the trunk of the splenic artery are the ones most liable to rupture Since calcifications in the wall usually go unnoticed the value of angiography in the diagnosis of aneurysms is obvious Celiac angiography is thus indicated in all cases of portal hypertension because aneurysms are so common in this condition

It is widely believed that splenoportal phlebography provides all the necessary information on hepatic cirrhosis and portal hypertension, but judging from our experience this would not seem to be correct It is known that splenoportal phlebography carries a risk of intrasplenic aneurysms (BOIJSEN & EFSING) The high frequency of aneurysms in the splenic hilum in patients with portal hypertension should also be borne in mind It has been recommended that at splenoportal phlebography the tip of the puncture needle or catheter be placed as close as possible to the hilum This must surely involve the risk of puncture of an extrasplenic hilar aneurysm and risk of uncontrollable intra abdominal haemorrhage It is quite possible that the massive haemorrhage known to have occurred at splenoportal phlebography, as described by LEGER et coll (1964, 1966), and others, may have been caused by such a puncture Arteriovenous fistulae have occurred in the hilum after splenoportal phlebography (CHAIT & MARGULIS 1966) An arterio venous fistula is liable to develop more easily if an aneurysm is punctured If therefore, the investigation of a patient with portal hypertension demands splenoportal phlebography there is every reason to perform celiac angiography first in order to clarify the anatomy of the splenic artery and spleen Angiography may in selected patients make splenic puncture unnecessary in the investigation of portal hypertension Celiac angiography also provides valuable information on the arterial circulation of the spleen and liver and, by the injection of bradykinin (Sandoz) before the injection of contrast medium into the superior mesenteric artery, it has been found possible to obtain good information on the venous system (BOIJSEN & REDMAN 1966)

OWENS & COFFEY (1953), in a review of the literature, noted some form of

FELDMAN M Aneurysm of the splenic artery an autopsy study Amer J dig Dis 22 (1955) 48
FERRARI E Contributo alla conoscenza degli aneurismi dell arteria lienale Cuore e circol 22 (1938) 585
HUGHES E S R and JOSKE R A Aneurysm of the splenic artery and chronic pancreatitis with a report of successful surgical resection Med J Aust 2 (1955) 188
KUPIC E A MARSHALL W H and ABRAMS H L Splenic arterial patterns Angiographic analysis and review Invest radiol 2 (1967) 70
LEGER L Splenoportography Charles Thomas Springfield 1966
— PREMONT M et ALPÉROVITCH R Ruptures spléniques apres spleno-portographie J Chir (Paris) 87 (1964) 107
LENNIE R A and SHEEHAN H L Splenic and renal aneurysms complicating pregnancy J Obstet Gynec 49 (1942) 426
LOWER W E and FARRELL J I Aneurysm of the splenic artery Report of a case and review of the literature Arch Surg 23 (1931) 182
MOORE S W and LEWIS R J Splenic artery aneurysm Ann Surg 153 (1961) 1033
OLIN T E and REUTER S R Splenic infarction secondary to a splenic artery aneurysm Vasc Dis 3 (1966) 269
OWENS J C and COFFEY R J Aneurysm of the splenic artery including a report of 6 additional cases Int Abstr Surg 97 (1953) 313
ROSSEN J R von The roentgen diagnosis of calcified aneurysms of the splenic and renal arteries Acta radiol 39 (1953) 385
ROSCH J und BRET J Unsere Erfahrungen mit der Milzarteriographie in der Diagnostik der Milzerkrankungen Fortschr Rontgenstr 97 (1962) 239
— Roentgenology of the spleen and the pancreas Charles Thomas Springfield 1967
SHEPS S G SPITTEL Jr J A FAIRBAIRN J F and EDWARDS J E Aneurysms of splenic artery with special reference to bland aneurysms Proc Mayo Clinic 33 (1958) 381
SHERLOCK S P V and LEARMONTH J R Aneurysm of the splenic artery with an account of an example complicating Gaucher s disease Brit J Surg 30 (1942) 151
SHERWIN B and GORDIMER H Aneurysm of the splenic artery Report of two cases Ann Surg 131 (1950) 599
SMITH G W and HILL C H Aneurysms of the branches of the abdominal aorta Diagnosis management and results Surgery 61 (1967) 509
SMITH P G EVANS A T ELSEY E C and FELSON B Translumbar arteriography its roentgenologic interpretation Amer J Roentgenol 67 (1952) 183
SPITTEL Jr J A FAIRBAIRN J F KINCAID O W and REMINE W H Aneurysm of the splenic artery J amer Med Ass 175 (1961) 452
— — SHEPS S G KINCAID O W and REMINE W H Splenic artery aneurysm Surg Clin N Amer 41 (1961) 1121
TAGART R E B Ruptured splenic arterial aneurysm Brit J Surg 39 (1952) 469
WAGNER Jr F B Arteriography in renal diagnosis preliminary report and critical evaluation J Urol 56 (1946) 625
WARD-MCQUAID J N Splenic arterial aneurysm Brit Med J (1958) 1448
YANG J SPINUZZA S J and GILCHRIST R K Aneurysm of splenic artery with calcification Arch Surg 87 (1963) 676

SUMMARY

Extrasplenic aneurysms of the splenic artery were observed in 9 instances in a consecutive series of 192 patients subjected to celiac angiography for different reasons A review of a further 115 such examinations performed for portal hypertension revealed extrasplenic aneurysms in 17 instances Only a few calcifications were seen The high incidence of aneurysms in hepatic cirrhosis with portal hypertension emphasizes the importance of celiac angiography

ZUSAMMENFASSUNG

In einer konsekutiven Serie von 192 Patienten bei denen aus verschiedenen Gründen Angiographie der A coeliaca vorgenommen war wurden in 9 Fällen extralienale Aneurysmen der Milzarterie beobachtet Beim Übersicht von 115 weiteren Fällen die wegen portalen Hochdruckes mit Angiographie untersucht wurden fand man noch 17 Fälle von Aneurysmen Nur ausnahmsweise wurden Verkalkungen in der Wand gesehen Das häufige Auftreten von Aneurysmen bei der Leberzirrhose dürfte den Wert der angiographischen Untersuchung der A coeliaca hervorheben

RÉSUMÉ

Les auteurs ont trouvé 9 cas d'anévrysmes extra-spléniques de l'artère splénique sur une série consécutive de 192 malades qui avaient subi une angiographie coeliaque pour différentes raisons L'examen d'une autre série de 115 cas d'angiographie coeliaque faite pour hypertension portale a montré des anévrysmes extra-spléniques dans 17 cas Les auteurs ont trouvé peu de calcifications dans les parois des anévrysmes La grande fréquence des anévrysmes dans la cirrhose hépatique avec hypertension portale démontre l'intérêt de l'angiographie coeliaque

REFERENCES

BAUM S GREENSTEIN R H NUSBAUM M and BLAKEMORE W S Diagnosis of ruptured noncalcified splenic artery aneurysm by selective arteriography Arch Surg 91 (1965) 1026

BERGER J S FORSEE J H and FURST J N Splenic arterial aneurysm Ann Surg 137 (1953) 108

BOIJSEN E and ERSING H O Intrasplenic arterial aneurysms following splenoportal phlebography Acta radiol Diagnosis 6 (1967) 487

— and REDMAN H C Effect of bradykinin on celiac and superior mesenteric angiography Inv radiol 1 (1966) 422

BYERS R M and BUXTON R W Review of splenic artery aneurysms with an additional seven case reports Amer Surgeon 33 (1967) 247

CHAIT A and MARGULIS M Splenic arteriovenous fistula following percutaneous splenoportography Radiology 87 (1966) 518

CULVER G J and PIRSON H S Splenic artery aneurysm Radiology 68 (1957) 217

DORMAN B A and CARNEY W I Aneurysm of the splenic artery Dis chest 48 (1965) 78

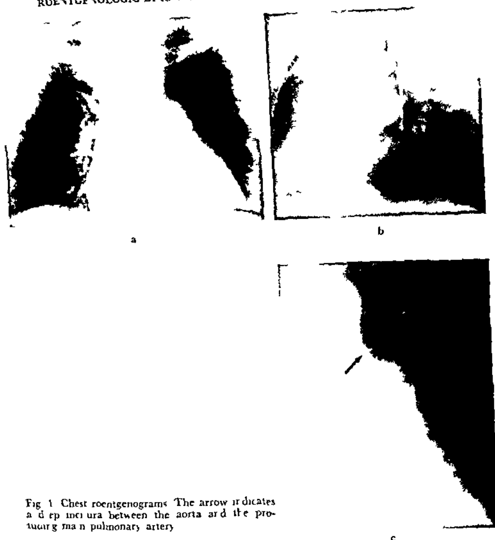


Fig 1 Chest roentgenograms The arrow indicates a deep incisura between the aorta and the protruding main pulmonary artery

due to partial left defects have however been described (BOXALL 1887 SUNDERLAND & WRIGHT SMITH 1944) Both were caused by herniation of the heart and the pulmonary artery Pericarditis accompanied the pericardial defect in 74 per cent of an autopsy series (SOUTHWORTH & STEVENSON) In the majority of these adhesions were present at the site of the defect

Certain roentgenologic signs characteristic of a pericardial defect have been described With the pericardium totally absent on the left side the heart may lie

FROM ROENTGEN DEPARTMENT I (DIRECTOR: PROF. O. BARTLEY), SAHLGRENSKA SJUKHUSET, GOTHENBURG, SWEDEN

ROENTGENOLOGIC DIAGNOSIS OF CONGENITAL PERICARDIAL DEFECT

Description of a case

by

N. E. AHLBERG, O. BARTLEY and S. PAULIN

Congenital pericardial defects are rare and only about 120 cases have been described. They occur about three times more often in men than in women (BARGMANN & DOERR 1963, TABAKIN et coll. 1965). If cases of ectopia cordis nuda are excluded, all of the defects are partial; the majority occur only on the left side but right defects of small size have recently been described (GRUBER 1949, JONES 1955, HIPONA & CRUMMY JR. 1964). SOUTHWORTH & STEVENSON (1938) divided the left defects into total and partial. The former, which occur three times more often than the latter, must mean that the left part of the heart and the left lung are situated in a common cavity. The partial defect usually occurs at the level of the left auricle and the pulmonary conus and artery. Other situations have been described, however, e.g. corresponding to the apical part of the right ventricle (KJELLBERG et coll. 1959).

Only a few cases of pericardial defects present clinical signs due to the anomaly (CHANG & LEIGH 1961, FOWLER 1962). The diagnosis has generally been made at autopsy or thoracotomy indicated by other disorders. Two deaths

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as the movements of the left ventricle No movements typical of the left auricle or pulmonary artery were demonstrated (Fig 2) Repeated postoperative roentgenologic examinations of the heart revealed no change

Discussion

A congenital pericardial defect is due to non fusion of the pericardial precursors SCHORN (1963) has reviewed the literature on the subject and summarized hypothetic explanations suggesting the following possibilities (1) unusually rapid development of the embryologic lung tissue (2) influence of the liver on the development of the pericardial membrane and (3) premature inversion of the left duct of Cuvier The latter event would delay the development of the left pericardial membrane which in turn would prevent the closure of the left pleuro-pericardial foramen This theory has generally been considered the most plausible since the defects almost without exception are situated on the left side An analogous malformation on the right side would be incompatible with life since the right duct of Cuvier becomes the superior vena cava When a congenital pericardial defect exists the phrenic nerve passes either along the free edge of the membrane or near the anterior thoracic wall On the other hand if secondary fenestration of the pericardium occurs the nerve follows its usual course i e laterally between the pericardium and the mediastinal pleura The defect was probably congenital in the present case since the nerve ran ventral to it

Cases of pericardial defects may also have other malformations (ELLIS et coll, inter alios) and these may dominate the clinical as well as the roentgenologic picture Cardiac malformations have been observed in the form of Fallot s tetrad (HIPONA & CRUMMY Jr) patent ductus arteriosus (KJELLBERG et coll CHANG & LEIGH) and abnormally draining pulmonary veins (TABAKIN et coll) In addition to a pericardial defect many cases have congenital pulmonary cysts of various kinds (RUSBY & SELLORS 1945 JONES 1955) and aberrant pulmonary lobes have also been described (BREA et coll 1958) JONES observed pericardial defects in five out of 19 cases of congenital pulmonary cysts Only exceptionally have pericardial defects occurred without other malformations (HERING et coll 1960)

The partial defect is practically always situated at the level of the pulmonary artery and since the contour is often prominent such a defect may be mistaken for a widening of this artery The differential diagnosis may therefore include pulmonary stenosis, pulmonary embolism pulmonary hypertension left right shunt and so-called idiopathic pulmonary dilatation Similar appearances may also be evident in abnormal positioning of the heart due to a diminished sagittal thoracic diameter or expansive process situated near the pulmonary artery The majority of these conditions should be clinically or roentgenologically defined or

far to the left, despite the fact that the trachea is on the midline, and it is moreover abnormally moveable in the left hemithorax (ABBOTT 1915, ELLIS et coll 1959, TABAKIN et coll) The contours of the heart and the vessels on the left side bulge due to the absence of the pericardium FOWLER (1962), and FELSON (1962) have described separation between the aortic arch and the pulmonary artery FOWLER has also observed interposition of left lung tissue between the diaphragm and the left ventricle The size of the heart is often somewhat increased (ABBOTT, ELLIS et coll, TABAKIN et coll) and fluoroscopy may reveal considerable excursions of the left side of the heart The latter changes presumably occur because of the absence of the support of the pericardium so that increased filling of the left ventricle occurs during diastole and the stroke volume is increased

The roentgenologic appearances of the left or right partial defects are less obvious No changes may be detected (VENTURINI & PESCI 1957) although a prominence of the cardiac or vessel contours, corresponding to the defect, is often evident (HERING et coll 1960, CHANG & LEIGH, inter alios) Exceptionally, herniation of the lung tissue into the defect may be revealed (HIPONA & CRUMMY Jr) A recent case of left partial pericardial defect, which was surgically verified, is described in this case report

Case report

A man aged 44 with infection of the upper respiratory tract was referred for roentgen examination No pulmonary changes were observed but the heart was somewhat enlarged (470 ml/m body surface) A lateral ventral bulge of the contour of the left auricle and pulmonary artery was present the upper part of the pulmonary artery was particularly clearly outlined and markedly convex upwards The vessel distribution in the lungs was normal (Fig 1) and the nature of the bulge could not be determined Heart sounds normal blood pressure 140/90 and pulse frequency about 65/min The rhythm was regular and the ECG normal

Cinematography of the heart with a picture frequency of about 80/sec was carried out in a further attempt to analyse the nature of the bulge The latter moved similarly to the left ventricle but inversely with the arch of the aorta Heart catheterization and angiocardiography were recommended but not performed

Since a mediastinal tumour could not be definitely excluded left exploratory thoracotomy was undertaken (Docent N P BERGH) No tumour was revealed but a partial defect of the pericardium corresponding to the left auricle and pulmonary conus was present The defect was approximately 7 cm × 7 cm in size and bound by adhesions the phrenic nerve lay ventrally embedded in thick fatty tissue The presence of the pericardial adhesions minimized the danger of cardiac herniation and the defect was left untreated The post operative course was uneventful

Electrokymography was carried out after the operation The movements at every part of the pericardial defect investigated were synchronized with and were of the same type

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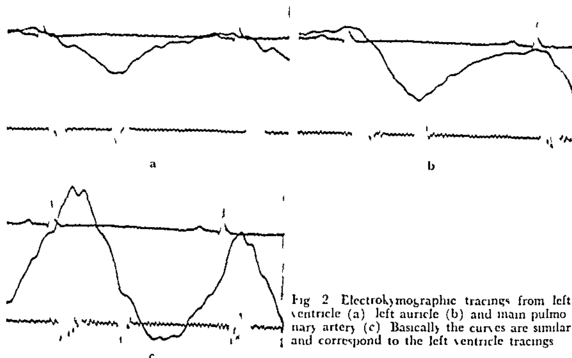


Fig 2 Electrokymographic tracings from left ventricle (a) left auricle (b) and main pulmonary artery (c) Basically the curves are similar and correspond to the left ventricle tracings

excluded, although differential diagnostic difficulties exist particularly in relation to idiopathic pulmonary dilatation and expansive processes

Angiocardiography is of value for estimating whether or not the prominent contours are caused by the pulmonary artery Pericardial defects have often been diagnosed in this manner (HERING et coll, inter alios) KJELLBERG et coll reported a case in which such a defect was a secondary finding at angiocardiography performed for other indications

A left artificial pneumothorax has been employed for the diagnosis of large defects ELLIS et coll were first to use this method although it had previously proved useful with other indications (DAHL 1937, RUSBY & SELLORS SHANKS & KERLEY 1951) The method has not been used for partial defects, but HERING et coll in one case observed gas in the defect postoperatively and stated that a pneumothorax might be of diagnostic value as in cases with large defects The possibility of the gas penetrating the defect depends however on the presence of pericardial adhesions

An obvious prominence corresponding to the pulmonary artery was present in this case of a left partial defect and as in some earlier descriptions of large defects, a large incisura between the descending aorta and the pulmonary artery existed Abnormal movements of the contour at the site of the defect were observed both with cinematography and electrokymography

The movements were reversed with those of the aortic arch but were syn

chronous with those of the left ventricle Similar observations have been made earlier by CHANG & LEIGH With an expansive process adjacent to the pulmonary artery the contour must either be stationary or which is more common move rhythmically with the heart or vessel section situated near the process Abnormal movements have earlier been observed by electrokymography in adhesive pericarditis without any pericardial defect (BARTLEY 1957) In the present case, operation revealed abundant adhesions at the site of the defect, and these were in all probability the reason why the movements were synchronous with and of the same type as those of the left ventricle Electrokymography therefore affords information on the presence of pericardial adhesions that generally occur with a pericardial defect If attention is paid to other roentgenologic changes in this condition electrokymography may be of decisive diagnostic importance

SUMMARY

A case of congenital left partial pericardial defect is described A study of the movements of the heart contour particularly by electrokymography may be of decisive diagnostic importance in cases with pericardial adhesions at the site of the defect

ZUSAMMENFASSUNG

Ein Fall von linkseitigem kongenitalen Perikarddefekt wird beschrieben. Die Diagnose *kann durch die* Untersuchung der Bewegungen der Herzkontur besonders mittels Elektrokymographie in solchen Fällen gestellt werden wo perikardiale Verwachsungen an der Stelle des Defektes vorliegen

RÉSUMÉ

Presentation d'un cas de défaut congenital partiel gauche du péricarde L'étude des mouvements du contour cardiaque en particulier par électrokymographie peut avoir une importance décisive pour le diagnostic dans les cas ou il y a des adhérences péricardiques dans la région du défaut

REFERENCES

ABBOTT M Congenital cardiac disease *In* Modern medicine Its theory and practice Original contributions by American and foreign authors Second edition Vol 4 p 344 Edited by W Osler assisted by T McCrae Lea & Febiger Philadelphia and New York 1915

BARGMANN W and DOERR W Das Herz des Menschen G Thieme Verlag Stuttgart 1963

BARTLEY O Om formakselektrokymogrammet vid konstriktiv pericardit (Swedish) Nord Med 57 (1957) 408

BOXALL R Incomplete pericardial sac escape of heart into left pleural cavity Trans obstet Soc Lond 28 (1887) 209

BREA M M CROXATTO O C e DE ALL J A Lobulo pulmonar abberrante con defecto pericardio D a med 30 (1958) 2734

CHANG C H and LEIGH I F Congenital partial defect of the pericardium associated with herniation of the left atrial appendage Amer J Roentgenol 86 (1961), 517

DAHL E Ett tilfelle av medfodt pericarddefekt diagnostisert efter anlegg av venstresidig pneumothorax Med Rev (Bergen) 54 (1937), 312

ELLIS K, LEEDS N L and HIMMELSTEIN A Congenital deficiencies in parietal pericardium review with 2 new cases including successful diagnosis by plain roentgenography Amer J Roentgenol 82 (1959) 125

FELSON B (1962) Personal communication

FOWLER O N Congenital defect of the pericardium Its resemblance to pulmonary artery enlargement Circulation 26 (1962), 114

GRUBER C B Zur Kenntnis kranialer Doppelbildung beim Menschen mit Zwerchfellsfehlern und mit Herzbeutel Lunge Beitr path Anat 110 (1949) 346

HERING A C WILSON J S and BALL JR R I Congenital deficiency of pericardium J thorac Surg 40 (1960), 49

HIPONA F A and CRUMMY JR A B Congenital pericardial defect associated with tetralogy of Fallot Herniation of normal lung into the pericardial cavity Circulation 29 (1964) 132

JONES P Developmental defects in the lungs Thorax 10 (1955) 205

KJELLBERG S R MANNHEIMER L, RUDHE U and JONSSON B Diagnosis of congenital heart disease Second edition Year Book Publishers Chicago 1959

RUSBY N L and SELLORS T H Congenital deficiency of pericardium associated with bronchogenic cyst Brit J Surg 32 (1945) 357

SCHORN J Pathologie des Herzhullen Das Herz des Menschen Edited by W BARGMANN and W DOERR G Thieme Verlag Stuttgart 1963

SHANKS S C and KERLEY P Textbook of X ray diagnosis p 146 Second edition W B Saunders Company Philadelphia 1951

SOUTHWORTH H and STEVENSON C S Congenital defects of pericardium Arch intern Med 61 (1938) 223

SUNDERLAND S and WRIGHT SMITH R J Congenital pericardial defects Brit Heart J 6 (1944) 167

TABAKIN B S HANSON J S TAMPAS J P and CALDWELL F J Congenital absence of the left pericardium Amer J Roentgenol 94 (1965) 122

VENTURINI A and PESCI A Le agenesie del pericardio Arch Chir Torace 14 (1957) 189

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AORTIC INSUFFICIENCY AS A COMPLICATION OF THE AORTITIS SYNDROME

by

TAKAHIRO KOZUKA and TADAHARU NOSAKI

The extensive arterial changes in the aortitis syndrome Takayasu s arteritis produce various clinical manifestations among which aortic insufficiency is rare Thirty-one cases have been found in the literature Aortic insufficiency was almost always detected by typical diastolic murmurs in the aortic region angiographic evidence of aortic insufficiency being described in only two cases DANARAJ et coll 1963 and SHAH et coll 1967)

Our observations in five cases of aortic insufficiency associated with the aortitis syndrome are now presented

Materials and Methods The series comprised 62 cases of the aortitis syndrome which were examined by conventional radiography of the chest and by aortography Fifty two of the subjects were females and ten were males all being Japanese The ages ranged from 10 to 51 years with an average of 28 years In forty of the entire series thoracic aortograms were obtained by injection of con trast medium above the aortic valve Aortic insufficiency was in four cases dis-

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Table

Major radiologic findings and clinical data in five cases (all females) of aortic insufficiency

Case	Age	Diastolic murmurs	Blood pressure right brachial artery mm/Hg	Conventional radiography		Thoracic aortography	
				Calcification of the aortic wall	Left ventricular enlargement	Regurgitation to left ventricle	Dilatation of the ascending aorta
1	51	—	120/30	Arcus	+	+	—
2	34	+	170/80	—	+	+	+
3	36	—	128/0	Descending	+	+	+
4	22	—	120/52	—	+	+	+
5	36	+	204/0	Entire thoracic	+	Not performed	

closed by filling of the left ventricle with the regurgitant medium An additional case was revealed by typical diastolic murmurs at the aortic ostium and conventional roentgenography of the chest without aortography

Results

The clinical data and the major radiologic findings related to the aortic insufficiency are listed in the Table above Characteristic diastolic murmurs indicating aortic insufficiency were audible in Cases 2 and 5 A common feature in the five cases was low diastolic blood pressure with resultant widely varying pulse pressure

Left ventricular enlargement was common in all the cases A jagged or wavy outline of the descending thoracic aorta was present as a direct roentgenologic *sign of the syndrome in three of the five cases, and extensive calcification of the* aortic wall throughout the entire thoracic aorta was observed in one of them Aortography disclosed dilatation of the ascending aorta in three cases and slight regurgitation into the left ventricle to indicate aortic insufficiency in all the cases in which aortography was performed

Case 4 had a marked aneurysmal dilatation of the entire thoracic aorta The degree of regurgitation was so *slight that the left ventricle was only faintly and* partially filled, but the contrast medium was not cleared away by the subsequent systole

Deformity and irregular contours of the aortic cusps suggesting postinflammatory changes were detected in Case 3 and Case 4



Case 2 Regurgitation of contrast medium from the ascending aorta into the left ventricle the left coronary artery was not outlined increase in width o the right coronary artery

Except for Case 5 in which there was no evidence of weakened or absent pulses of the extremities four cases investigated with aortography had obliteration of the left subclavian artery

Case 2 might have had obstruction of the left coronary artery the latter failed to fill and there was marked dilatation of the right coronary artery

Discussion

Loud systolic or sometimes continuous murmurs due to stenosis of the thoracic aorta or its main tributaries occur in the aortitis syndrome These may subsequently conceal diastolic murmurs caused by aortic incompetence Furthermore diastolic murmurs may sometimes be too indistinct to be detected From this point of view thoracic aortography has advantages over auscultation When typical diastolic murmurs cannot be heard low diastolic blood pressure with

resultant widely varying pulse pressure may be of importance for the detection of aortic insufficiency, provided the blood pressure has been recorded.

If aortic incompetence is present, thoracic aortography will disclose regurgitation of the contrast medium into the left ventricle and also precisely define the thoracic aorta and the brachiocephalic arteries. Regurgitation of the contrast medium may occur as an artefact, however, either because of aortic incompetence induced by contact of the tip of the catheter with an aortic cusp, or by an extrasystole during the injection. This should be distinguished from true organic regurgitation.

Two factors in the etiologic origin of aortic insufficiency associated with the aortitis syndrome may be considered. One factor is dilatation of the ascending aorta and enlargement of the left ventricle, causing separation of the aortic commissures. Dilatation of the ascending aorta is not uncommon in this syndrome (KOZUKA et coll. 1966). In the cases in which involvement of the aortic valve has been absent at autopsy (YAMADA et coll. 1961), separation of the aortic commissures might have played an important role. The other factor is contraction of the aortic valve by extension of an inflammatory process (JUDGE et coll. 1962). Deformity and rigid contours of the aortic valves, as demonstrated aortographically in Case 3 and Case 4, may indicate such a condition.

Involvement of the coronary artery ostium, as suggested in Case 2, has been described (CASE RECORDS OF THE MASSACHUSETTS GENERAL HOSPITAL 1961, CHITTLIN & CARTER 1965). Calcification of the wall of the ascending aorta, the presence of which in this syndrome was denied by GILLANDERS & STRACHAN (1965), occurred in Case 5. Although this would not, of course, be directly related to the diagnosis of aortic insufficiency, such an extensive lesion of the ascending aorta might involve the aortic cusps and thus cause aortic insufficiency.

The incidence of aortic incompetence in this syndrome is 9 out of 11 cases *and among the several diseases that may cause aortic insufficiency it has been* ranked third after rheumatism and syphilis (UEDA et coll. 1967). Aortic insufficiency caused by other factors than the aortitis syndrome may incidentally coexist and must be distinguished from a complication of the syndrome itself. In a strict sense a case described by TISSOT (1959), because of its rheumatic nature, ought to be excluded. Needless to say the history should be carefully examined.

This complication of aortic incompetence may lead to cardiac failure and an accurate diagnosis is required. Aortic insufficiency as a complication of the aortitis syndrome cannot be diagnosed in conventional roentgenograms of the chest, since a dilated aorta and an enlarged left ventricle frequently occur without aortic insufficiency. Therefore, thoracic aortography with injection of the contrast medium above the aortic valve is indispensable.

SUMMARY

Observations in five cases of aortic insufficiency in a material of 62 cases of the aortitis syndrome are presented and the important role of thoracic aortography in the detection of this complication is stressed. Etiological factors are discussed.

ZUSAMMENFASSUNG

Beobachtungen in fünf Fällen von Aorteninsuffizienz in einem Material von 62 Fällen von dem Aortitis Syndrom werden vorgelegt und der Wert thorakaler Aortographie um diese Komplikation feststellen zu können wird betont. Ätiologische Faktoren werden besprochen.

RÉSUMÉ

Les auteurs présentent cinq cas d'insuffisance aortique sur une série de 62 cas de syndrome d'aortite. Ils insistent sur le rôle important de l'aortographie thoracique dans la détection de cette complication. Ils étudient l'étiologie de cette affection.

REFERENCES

CASE RECORDS OF THE MASSACHUSETTS GENERAL HOSPITAL. New Engl J Med 264 (1961) 664.

CHEITLIN M D and CARTER P B Takayashu's disease Arch intern Med 116 (1965) 283

DANARAJ T J WONG H O and THOMAS M A Primary arteritis of aorta causing renal artery stenosis and hypertension Brit Heart J 25 (1963) 153

GILLANDERS L A and STRACHAN R W The role of radiology in the diagnosis of Takayasu's arteriopathy (pulseless disease) Clin Radiol 16 (1965) 119

JUDGE R D CURRIER R D GRACIE W A and FIGLEY M M Takayasu's arteritis and the aortic arch syndrome Amer J Med 32 (1962) 379

KOZUKA T NOSAKI T SATO K and IHARA K Roentgenologic diagnosis of atypical coarctation of the aorta Acta radiol Diagnosis 4 (1966) 497

— — — and TACHIIRI H Aneurysm associated with aortitis syndrome Acta radiol Diagnosis 7 (1968) 314

LESSOF M H The pulseless syndrome Lancet 1959 I p 799

SHAH V V SHAH K D and SHAH C V Aortic arch syndrome with aortic incompetence Vasc Dis 4 (1967) 1

UEDA H ITO I SUGIURA M et coll Aortic insufficiency associated with aortitis syndrome Jap Circulation J 31 (1967) 552

YAMADA H HARUMI K OHTA A et coll Aortic arch syndrome with cardiomegaly and aortic calcification Jap Heart J 2 (1961) 538

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LUMBAR MYELOGRAPHY WITH WATER-SOLUBLE CONTRAST MEDIA

With special reference to the appearances of root pockets

by

C Hirsch, M Rosencrantz and I Wickbom

The report by Mixter & Barr in 1934 that sciatica may be caused by disc herniation and that its removal may relieve the symptoms of the patient produced a wave of enthusiasm for this kind of surgery throughout the world The diagnosis is often made with great accuracy from the symptoms and signs and by careful neurologic examinations (Norlén 1944) However disc herniation is not always responsible for the symptoms and if present its correct spinal level may be difficult to determine A great number of negative surgical explorations have been performed over the years and illustrate the fact that sciatica is not synonymous with disc prolapse Furthermore a negative finding at one level necessitates the exploration of several interspaces Often the surgeon has to accept the possibility of a concealed disc or faces the problem of evaluating minor deformations of the posterior aspect of the disc which may be unassociated with the prolapse although they may lead to excision This is naturally less favourable to the patient than the removal of a true prolapse (Friberg & Hirsch 1946)

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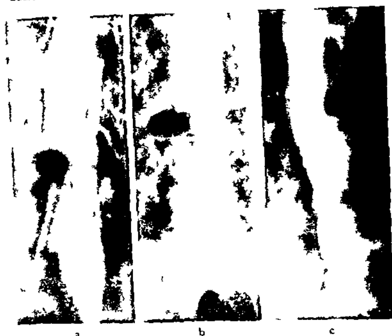


Fig 1 Disc herniation at L4—L5 on right side a) Oblique view horizontal beam Patient in right recumbent position rotated forward about 15 marked local indentation at the L4—L5 interspace the root pocket to the L5 root is not filled b) Corresponding view of the left side Normal appearances c) Lateral view prone Slight anterior indentation at L4—L5

Combined procedures e g disc removal and fusion have often been performed in these conditions with unpredictable and usually discouraging end results

Several radiologic diagnostic methods have been introduced to avoid this kind of surgery a fact that in itself indicates that none of them has been ideal Large herniations situated medially generally deform the dural sac in such a way that they are easily detected by any myelographic technique Small herniations on the other hand especially if located laterally may not alter the shape of the dural sac at all although they usually compress the root pocket The demonstration of such a herniation therefore demands the outlining of the root and the root pocket as completely as possible Water soluble contrast media because of their low viscosity mix well with the cerebrospinal fluid A more complete view of the root pockets may therefore generally be better achieved with such media than with iodized oil compounds they possess in addition the advantage of being spontaneously absorbed within some hours (ARNELL 1944 1948 LIND

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by

C HIRSCH, M ROSENCRANTZ and I WICKBOM

The report by MIXTER & BARR in 1934 that sciatica may be caused by disc herniation and that its removal may relieve the symptoms of the patient produced a wave of enthusiasm for this kind of surgery throughout the world The diagnosis is often made with great accuracy from the symptoms and signs and by careful neurologic examinations (NORLEN 1944) However, disc herniation is not always responsible for the symptoms and, if present, its correct spinal level may be difficult to determine A great number of negative surgical explorations have been performed over the years and illustrate the fact that sciatica is not synonymous with disc prolapse Furthermore a negative finding at one level necessitates the exploration of several interspaces Often the surgeon has to accept the possibility of a concealed disc or faces the problem of evaluating minor deformations of the posterior aspect of the disc which may be unassociated with the prolapse although they may lead to excision This is naturally less favourable to the patient than the removal of a true prolapse (FRIBERG & HIRSCH 1946)

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Fig 3 Disc herniation at L4—L5 Small indentation clearly seen in (a) where beam was parallel to this disc but not in (b) where beam was parallel to the L5—S1 disc In the latter view the normal S1 root pocket is better demonstrated

Fig 4 The root pocket to the L5 root appears shorter on the right side (a) than on the left (b) No herniation was present at operation

in 15 instances leaving 489 surgical explorations in which the myelographic findings could directly be evaluated with those at operation This material appeared suitable for study since myelography was performed in every patient who was considered a candidate for surgery The ultimate decision whether to operate or not was made after consideration of the clinical signs and the myelographic changes Operation was sometimes performed in spite of negative myelography because of severe symptoms mostly during more than six months of incapacity Only mild symptoms and minor myelographic changes sometimes indicated the continuation of conservative treatment

Myelographic technique The patient lies on a tilting table with the head end elevated 15 to 20° After lumbar anaesthesia with 2 ml heavy xylocain 10 ml Kontrast U (AB Leo Sweden) are slowly injected Films are obtained under fluoroscopic control with a horizontal beam the patient lying first on the affected side then prone and finally on the opposite side The films are exposed

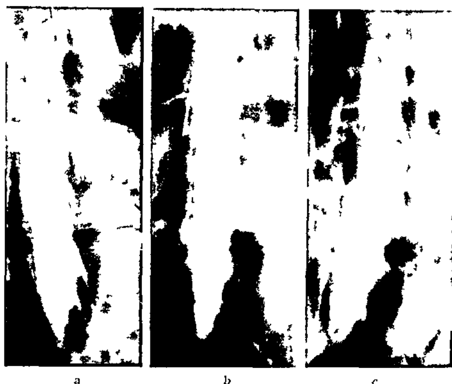


Fig. 2. Disc herniation at L 5—S1 on left side, patient in left recumbent position with various degrees of forward rotation. The small indentation at the disc level is clearly seen in (c), less well in (b) and not at all in (a); the corresponding root pocket (S1) is displaced laterally and compressed and the root is thickened.

BLOM 1946, KNUTSSON 1950/1951). The main disadvantage is the irritation they cause so that spinal anaesthesia is necessary. They can furthermore be used only for the lumbar region and hardly ever above L2; a fall in blood pressure is fairly common. More serious complications have also been reported but these have probably been due mainly to an inappropriate technique.

Several studies have been made to compare the myelographic and surgical findings (FRIBERG & HULT 1950, HIRSCH & NACHEMSON 1963, AMUNDSEN et coll. 1963). Since the myelographic changes did not always correspond to true herniated discs at operation, we decided to investigate the reliability of the *method and especially the significance of changes in the appearance of the root* pockets.

Five hundred and four patients in all, subsequently operated upon during a 3 year period (1962—1964), were reviewed. The total number of myelographic examinations performed in patients in the orthopaedic department for sciatica was 878 during the same period. The operation was performed for recurrences



Fig 6 Large indentation from in front mainly on the right side Only fibrosis and no herniation was seen at operation

III No or only incomplete filling of one root pocket but no indentation in the dural sac at this point small anterior indentations were however sometimes seen in the lateral view (Figs 2 to 5)

IV No or incomplete filling of one root pocket combined with a shallow indentation in the dural sac

V Marked deformation with more or less complete obliteration of the dural sac (Figs 6 and 7)

The surgical findings were divided into five groups

0 Normal findings with the root lying free in the epidural fat

1 Disc rupture with typical herniation

2 Disc protrusion usually causing a slight displacement of the root but no visible herniation

3 Fibrosis with the root more or less fixed by adhesions



Fig. 5. Disc herniation at L 4—L 5. Fairly large anterior indentation. Root pocket to the L 5 root appears shorter on the left side than on the right.

with different degrees of rotation of the patient in order to secure views with the root pocket projected free from the dural sac (Fig. 2). Care is taken to get the beam parallel to the discs and this usually requires two different degrees of angulation (Fig. 3). A fall in blood pressure is prevented by giving 1 ml ephedrine subcutaneously before the contrast medium injection. In spite of this, however, a fall may occur after the examination so it is necessary to watch the patient carefully for several hours following the procedure.

Results

The myelograms were reviewed and the classification was made by one of the authors (W) who had no knowledge of the clinical signs nor of the surgical findings. The results of the study are given in Table 1. The myelographic changes were classified as follows:

0. Normal findings with no deformation and normal appearances of the root pockets.

I. Typical changes with marked local indentation at the site of the root pocket and no or only incomplete filling of the pocket (Fig. 1).

II. Marked anterior indentation observed only in the lateral view but normal filling of the root pockets.



Fig 7 Large filling defect at the level of L3—L4 No lesion present at operation however

had a true prolapse Six patients had neither the Lasegue sign nor neurologic disorders two of these had a prolapse The rest of the group with myelographically defective filling of the root pocket (73 patients) had clinical signs clearly indicating root involvement in terms of both positive leg raising and neurologic disturbance In spite of this only 49 patients had a prolapse Al together prolapses were present in 65 per cent of those in whom myelography revealed only a short root pocket In the majority of the other patients, fibrosis at the disc level and root adhesions were evident at operation, which may at least to some extent explain the myelographic changes and the clinical signs

In order to find out whether a small difference could be found between cases with or without true herniation the myelograms of group III were again re viewed with special reference to the thickness of the corresponding root and the appearance of the root pockets One of the authors again had no knowledge of the surgical findings nor of the clinical signs The results of this repeat review appear in Table 2 The myelograms have in this table been divided into two groups More abrupt cessation of the contrast filling and as a rule a thickening

Table 1

Material grouped according to the myelographic changes (O—V) and the surgical findings (0—4) For definitions, see pp 58—59

	Surgical findings						
	Groups	0	1	2	3	4	Total
Myelographic interpretations	0	15	2	—	3	1	21
	I	1	264	—	—	—	265
	II	1	4	3	1	—	9
	III	9	71	8	18	2	108
	IV	1	36	2	15	1	55
	V	2	17	4	3	5	31
Total		29	394	17	40	9	489

Table 2

Cases with incomplete filling of the root pocket as the only myelographic finding A indicates somewhat more marked myelographic changes than B For definitions, see p 62

		Surgical findings in group III (cf Table 1)				
		0	1	2	3	4
Myelographic interpretations	A	2	44	1	6	—
	B	7	27	7	12	2

4 Miscellaneous changes including one neurinoma, anomalies, haematomas It was sometimes not quite clear from the surgical report to which group the case should be referred The surgeon in the team (H) decided on the grouping when doubt existed

Herniation was present in all but one of the cases with typical myelographic changes (Table 1) There is no explanation for the only exception Good correlation was found in the cases with a negative myelogram An interval of several months between the myelographic examination and operation occurred in the cases of true herniation

As previously mentioned, special attention was paid to the 108 cases with small myelographic changes, mainly consisting of more or less incomplete filling of the root pocket (group III) Only 29 of the patients in this group had a positive leg raising test, no neurologic disturbances such as muscle weakness loss of sensibility or absence of reflexes, were observed Twenty two of these 29 patients

3 Changes only of a root pocket are often (in about two-thirds of cases) but not necessarily caused by lateral herniation

4 Even with marked myelographic changes operation may occasionally fail to reveal a disc lesion

SUMMARY

The myelographic changes and the surgical findings were compared in a material of 489 patients considered clinically to have disc herniation Prolapse corresponding to the typical myelographic changes was confirmed at operation in 264 patients while in 108 patients with only slight myelographic changes 65 per cent were found to have true herniations. The discrepancies are discussed

ZUSAMMENFASSUNG

Die myelographischen Veranderungen in einem Material von 489 Patienten die klinische Zeichen von Diskushernien aufwiesen wurden mit den operativen Befunden verglichen Prolaps wurde bei der Operation in 264 Patienten bestatigt die im Myelogramm typische Veranderungen hatten In 108 Patienten mit nur geringen myelographischen Veranderungen lag bei 65 Prozent ein wirklicher Diskusprolaps vor Die Ursachen der Diskrepanz werden diskutiert

RÉSUMÉ

Les auteurs ont compare les signes myelographiques et les constatations per-operatoires sur une serie de 489 malades consideres cliniquement comme ayant une hernie discale Les signes myelographiques typiques de prolapsus discal ont ete confirmes a l operation chez 264 malades alors que 65 pour cent des 108 malades qui avaient seulement de petits signes myelographiques avaient reellement une hernie discale Les auteurs examinent les raisons de ces discordances

REFERENCES

AMUNDSEN P HILSINGEN P and KRISTIANSEN K Evaluation of lumbar radiculography (myelography) with water soluble contrast media Acta radiol Diagnosis 1 (1963) 609

ARNELL S Weitere Erfahrungen uber Myelographie mit Abrodil Acta radiol 25 (1944) 408

— Myelography with water soluble contrast with special regard to the normal roentgen picture Acta radiol (1948) Suppl No 75

CRONQVIST S The postoperative myelogram Acta radiol 52 (1959) 45

FRIBERG S and HIRSCH C On late results of operative treatment for intervertebral disc prolapses in the lumbar region Acta chir scand 93 (1946) 161

— and HULT L Comparative study of Abrodil myelogram and operative findings in low back pain and sciatica Acta orthop scand 20 (1950) 303

HIRSCH C and NACHEMSON A The reliability of lumbar disk surgery Clin Orthop 29 (1963) 189

of the root, existed in group A, there was also sometimes a suggestion of a small indentation at the origin of the root pocket In group B, the difference between the root pockets on the two sides was less marked, and the root was not thickened The correlation was somewhat better in group A than in group B (i e a higher incidence of herniation found at operation) although it still appeared impossible to distinguish with certainty between cases with and without true herniation It is evident, on the other hand, that a careful study of the root pockets is of great importance since changes in these were the only signs of a herniation in about 15 per cent, and the main finding in a further 5 per cent, of all the patients with disc herniation

It is indeed interesting and rather disappointing that herniation occurred only in slightly more than 50 per cent of the patients with very marked deformation and sometimes with almost complete obliteration of the dural sac (group V) It is well known that scar tissue after an earlier operation can cause such changes and simulate a recurrence The material includes 15 patients (not in the tables) with changes of this kind who had earlier had a herniation removed In seven patients recurrent herniations were present and in the remaining eight patients only scar tissue was present at the second operation This material has not confirmed CRONQVIST s opinion that a deformation at the disc level indicates herniation whereas scar tissue produces deformation somewhat above and below the disc We have not seen it reported in the literature that such marked changes may be produced by scar tissue without a previous operation Even more remarkable is the fact that exploration was almost completely negative in two of our patients with such a large deformation There appears to be no reasonable explanation for this One of these cases is briefly described below

The patient was a 42 year old man who had had pain radiating down the right leg to the knee joint for 6 months but otherwise no symptoms A large indentation at the level of the L3—L4 disc was demonstrated at myelography (Fig 7) This region was explored but no abnormality was found The patient s symptoms continued and myelography was repeated 6 months later with the same result A second operation was performed, this time by a neurosurgeon of great experience On this occasion the dura was also opened but only small postoperative changes were present The symptoms gradually disappeared

Conclusions

1 No disc prolapse was evident at operation in 17 per cent of the patients in spite of careful selection based on clinical and myelographic considerations

2 Typical changes of the kind shown in Fig 1 definitely indicate disc herniation

FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR PROF F KNUTSSON), THE UNIVERSITY HOSPITAL UPSALA, SWEDEN

SIZE OF INTERPEDUNCULAR, PONTINE, PONTOCEREBELLAR CISTERNS AND CISTERNA MAGNA IN CHILDHOOD

by

B CARLSSON and H LODIN

The suprasellar and interpeduncular cisterns are according to ROBERTSON deeper in children than in adults The central part of the pontine cistern is of the same depth in children as in adults while its lateral recesses on the other hand are greater in infants ROBERTSON presents no detailed analysis, however of the size of the cisterns during different stages of the growth period The subarachnoid spaces have been analysed fully by LILJEQUIST but his material includes no cases below the age of 15 years

The size of the suprasellar cisterns in the sagittal plane was also analysed indirectly in the investigation of changes in position of the third ventricle during the period of growth These cisterns are remarkably large during the first years of life but then become smaller by the displacement of the third ventricle in a basal and dorsal direction (LODIN 1968 Fig 3) The size of the interpeduncular pontine and pontocerebellar cisterns as well as the cisterna magna will be discussed in this communication

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KNUTSSON F Lumbar myelography with water soluble contrast in cases of disc prolapse Acta orthop scand 20 (1950/1951) 294

LINDBLOM K Lumbar myelography by Abrodil Acta radiol 27 (1946), 1

MIXTER W J and BARR J S Rupture of the intervertebral disc with involvement of the spinal canal New Engl J Med 211 (1934) 210

NORLEN G On the value of the neurological symptoms in sciatica for the localization of a lumbar disc herniation A contribution to the problem of the surgical treatment of sciatica Acta chir scand Suppl No 94, 1944

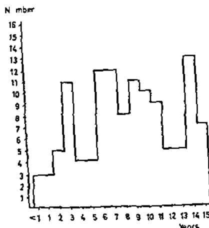


Fig 3 Age distribution in the interpeduncular cistern material

Results

Pontine cistern The height of this cistern was measurable in 125 cases (Fig 1) The measurements were made on lateral films obtained sitting in 112 cases and on lateral films obtained supine in 13 cases In these latter cases the gas filling of the cisterns had not been satisfactory in the films in sitting position One of these patients was 1 year old two were 3 years two 7 years, one was 8 years one 9 years two were 11 years one was 12 years one 13 years and two were 14 years old

The height of the cistern is given as the shortest perpendicular distance (Cl—P) between the clivus and the anterior contour of the pons The mean values for this distance in the different year groups are given in Fig 2

There is no noteworthy change in height of the pontine cistern during the growth period (Fig 2) It appears to have the same width, i e 5 mm even down to the lowest age groups The mean value in LILJEQUIST s adult series examined in the sitting position was also 5 mm

Interpeduncular cistern The size of this cistern was studied in 122 cases (Fig 3) In 112 cases the measurements were made on lateral films in sitting position and in 10 cases on lateral films obtained supine —Of the latter 10 patients one was 1 year old one 3 years two were 7 years one was 8 years, one 9 years one 10 years one 11 years one 12 years and one 13 years old

The size of the cistern was determined both by measuring certain absolute

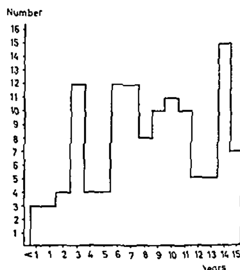


Fig 1 Age distribution in the pontine cistern material

Material The composition of the normal series of encephalographies upon which this study was based is given in Figs 1, 3, 6 and 8 No cases with sub dural air or markedly wide sulci are included The size of the cisterns was deter mined partly by measuring certain distances from given reference points in the cranial bones, and partly by calculating the ratios between these distances and certain reference lines within the cranium The means of the absolute values and ratios were calculated for each year group and are presented as curves No con sideration has been taken of the individual enlargement factors dependent on variations in skull size

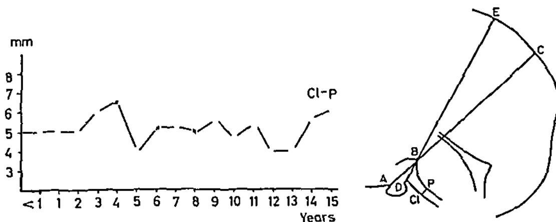


Fig 2 Width of pontine cistern in respective age groups mean values Cl—clivus P—pons

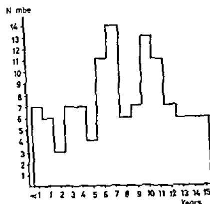




Fig 6 (left) Age distribution in the pontocerebellar cistern material

Fig 7 (right diagram) Width of pontocerebellar cistern mean values.

reference point used (Fig 4) LILIEQUIST measured the depth from the tip of the dorsum sellae in 107 cases his values varying from 14 to 23 mm with an estimated mean value of 19 mm This value in patients of the present material of ages below one year was 10 mm but after the age of 2 years it had increased to about 20 mm

The size of the interpeduncular cistern in relation to the cranial cavity is illustrated in Fig 5 During the first two years of life there is an increase in size in relation to the posterior cranial cavity, thereafter no change in the relative size occurs

Pontocerebellar cisterns The pontocerebellar cisterns were measured on frontal films in sitting position and with the central ray directed so that the superior contour of the pyramids was projected above the supraorbital margin Only films in this projection or in a projection differing only very slightly from it were used for the measurements (121 cases in all) (Fig 6)

The width of the pontocerebellar cisterns is given as the perpendicular distance from the pars petrosa immediately medial to the internal acoustic meatus A mean of the values on the two sides was used in the subsequent analysis in cases with different values on the right and left sides The lateral extension of the pontocerebellar cisterns was also studied by the method of group classification recommended by LILIEQUIST in patients of 4 years and under

The pontocerebellar cisterns are somewhat wider during the very first years of life as compared to the rest of childhood (Fig 7) A calculation of the mean width for all patients below 4 years of age gave an average of 7 0 mm while for the age group 5–15 years the corresponding values was 5 2 mm

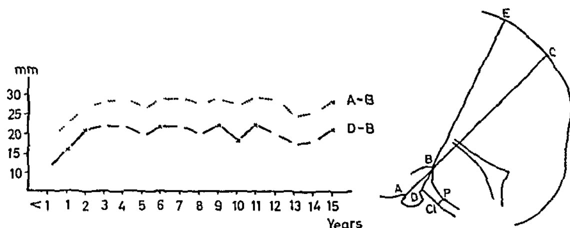


Fig 4 Width of the interpeduncular cistern mean values A—tuberculum sellae D—dorsum sellae B—bottom of interpeduncular cistern

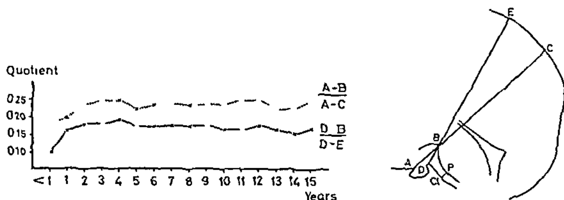


Fig 5 Size of interpeduncular cistern in relation to cranial cavity mean values A—tuberculum sellae D—dorsum sellae B—bottom of interpeduncular cistern

distances and by calculating the ratios between these distances and given reference lines within the cranium Thus, the distances from the tuberculum sellae (A) and the tip of the dorsum sellae (D) to the bottom of the interpeduncular fossa (B) were measured (Fig 4)

The relative size of the cistern was determined by calculating the ratios between these two distances (A—B, D—B) and the distances along the projected line (A—C, D—E) through the interpeduncular fossa to the inner surface of the skull

The depth of this cistern, measured in absolute values, increases somewhat during the first two years of life, after which it remains constant regardless of the

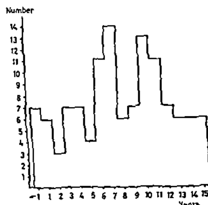




Fig 6 (left) Age distribution in the pontocerebellar cistern material

Fig 7 (right diagram) Width of pontocerebellar cistern mean values

reference point used (Fig 4) LILIEQUIST measured the depth from the tip of the dorsum sellae in 107 cases his values varying from 14 to 23 mm with an estimated mean value of 19 mm This value in patients of the present material of ages below one year was 10 mm but after the age of 2 years it had increased to about 20 mm

The size of the interpeduncular cistern in relation to the cranial cavity is illustrated in Fig 5 During the first two years of life there is an increase in size in relation to the posterior cranial cavity, thereafter no change in the relative size occurs

Pontocerebellar cisterns The pontocerebellar cisterns were measured on frontal films in sitting position and with the central ray directed so that the superior contour of the pyramids was projected above the supraorbital margin Only films in this projection or in a projection differing only very slightly from it were used for the measurements (121 cases in all) (Fig 6)

The width of the pontocerebellar cisterns is given as the perpendicular distance from the pars petrosa immediately medial to the internal acoustic meatus A mean of the values on the two sides was used in the subsequent analysis in cases with different values on the right and left sides The lateral extension of the pontocerebellar cisterns was also studied by the method of group classification recommended by LILIEQUIST in patients of 4 years and under

The pontocerebellar cisterns are somewhat wider during the very first years of life as compared to the rest of childhood (Fig 7) A calculation of the mean width for all patients below 4 years of age gave an average of 7 0 mm while for the age group 5—15 years the corresponding values was 5 2 mm

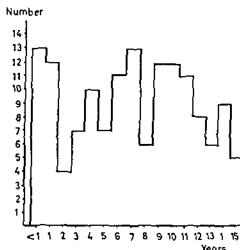


Fig 8 Age distribution in the cisterna magna material

In a comparison of the pontocerebellar cisterns of the right and left sides it was observed that the width was the same on both sides in 40 % of the cases while there was a difference of 1 mm in 50 % In 6 % a difference of 2 mm between the two sides was noted and in 4 % of the cases the difference amounted to 3 mm

In the analysis of the lateral extension of the cisterns in patients below 4 years of age, by the group classification method of LILIEQUIST, the following results were obtained Fifteen per cent were assigned to group III, i e the cistern extended a long distance laterally along the pars petrosa, and its lateral borderline was indistinct In a further four cases (just over 10 %), the cistern of one side was assigned to group III, and that of the other side to group II

The accuracy of measuring and evaluating the width of the pontocerebellar cisterns in the frontal projection may be questioned These cisterns vary in appearance, and apparently in width, depending on the projection of the central ray, as mentioned, identical projection conditions were always aimed at however Anatomical variations remain as possible sources of error but these should have been similar throughout the material The finding of a decrease in width after the first few years of life should thus be an expression of the anatomical development within the posterior cranial cavity The difference in width between the right and left cisterns, with 2 to 3 mm difference in 10 % of the cases reflects anatomical variations

As regards the lateral extension 15 % of the patients under 4 years of age belonged, according to the LILIEQUIST classification, unequivocally to group III This corresponds to the distribution in his adult material In a further 10 %, however, the lateral extension was asymmetric, the cistern of one side being assigned

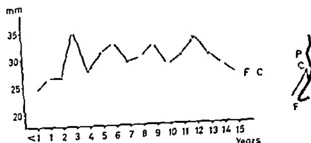


Fig 9 Absolute height of cisterna magna (F—C) mean values C—top of cistern F—posterior margin of foramen magnum



Fig 10 Height of cisterna magna (F—C) in relation to the distance between the internal occipital protuberance (P) and the posterior margin of the foramen magnum (F) mean values

to group III and that of the other side to group II The lateral extension in the youngest patients is therefore probably greater than in adults which agrees with ROBERTSON s opinion Since the enlargement factor in the material increases with increasing age this cannot have had any influence on the results

Cisterna magna The size of the cisterna magna was determined from lateral films in sitting position (146 cases) (Fig 8) The absolute height (F—C) of the cistern above the posterior margin of the foramen magnum was measured (Fig 9) This distance was then compared with the distance between the internal occipital protuberance (P) and the same point on the posterior margin (F) of the foramen magnum The ratio between these two distances was calculated (Fig 10) The cistern was thus analysed only in the sagittal plane Measurement of the cisterna magna in the frontal plane was not possible

The maximal height of the cistern, measured in absolute values, increases somewhat during the first years of life, and thereafter remains constant. The relative size conditions are illustrated in Fig. 10. No difference between the year groups was observed, the ratio between the two measured distances, viz. the height of the cisterna magna and the distance to the internal occipital protuberance from the foramen magnum was about 0.60, i.e. the height of the cistern was, on the average, a little more than half the distance from the foramen magnum to the internal occipital protuberance. The mean values for the absolute height were as follows: 0 to 2 years 24 mm, 0 to 4 years 26 mm, and 5 to 15 years 30 mm. In LILIEQUIST's adult material, the mean value was 28 mm.

The results indicate that the absolute height of the cisterna magna increases in small degree during the first years of life but that no change in size in relation to the growth of the posterior cranial cavity occurs throughout the entire growth period. This cistern thus develops at the same rate as the posterior cranial cavity.

Conclusions

During the first two years of life the depth of the suprasellar cisterns decreases, while at the same time the depth of the interpeduncular cistern increases, both absolutely and relatively. These changes in size coincide with the rapid growth of the cerebral hemispheres and the simultaneous displacement of the central parts of the cerebrum in a dorsal direction. The pontine cistern undergoes no change in depth despite the relative dorsal displacement of the aqueduct. This is explained by a simultaneous increase in volume of the pons. The pontocerebellar cisterns decrease somewhat, both in width and lateral extension after the age of two years. A relative increase in the volumes of the cerebellar hemispheres and pons in relation to the posterior cranial cavity may explain the change in size of these cisterns. Finally the cisterna magna follows the growth of the posterior cranial cavity, and its relative size remains unchanged during the growth period.

SUMMARY

The changes in size of the pontine, interpeduncular and pontocerebellar cisterns as well as the cisterna magna during the growth period in children are analysed and discussed with reference to a normal series of encephalographies.

ZUSAMMENFASSUNG

Die Grösseveränderungen der Cisternae pontis, interpeduncularis, pontocerebellaris und der Cisterna magna während der Wachstumsperiode der Kinder wurden an einer Serie von normalen Encephalographien analysiert und die Resultate werden diskutiert.

RÉSUMÉ

Les auteurs étudient et comparent a une serie d encéphalographies normales les modifications des dimensions des citernes prépontique interpedonculaire et ponto-cérebelleuses ainsi que de la grande citerne chez les enfants pendant la periode de croissance

REFERENCES

LILIEQUIST B The subarachnoid cisterns An anatomic and roentgenologic study Acta radiol (1959) Suppl No 185

LODIN H Size and development of the cerebral ventricular system in childhood Acta radiol Diagnosis 7 (1968) 385

— Normal topography of the cerebral ventricular system in childhood Acta radiol Diagnosis 7 (1968) 512

ROBERTSON E G Pneumocephalography Blackwell scientific publications Oxford 1957

The maximal height of the cistern, measured in absolute values, increases somewhat during the first years of life, and thereafter remains constant The relative size conditions are illustrated in Fig 10 No difference between the year groups was observed, the ratio between the two measured distances, viz the height of the cisterna magna and the distance to the internal occipital protuberance from the foramen magnum was about 0 60, i e the height of the cistern was, on the average, a little more than half the distance from the foramen magnum to the internal occipital protuberance The mean values for the absolute height were as follows 0 to 2 years 24 mm, 0 to 4 years 26 mm, and 5 to 15 years 30 mm In LILIEQUIST s adult material, the mean value was 28 mm

The results indicate that the absolute height of the cisterna magna increases in small degree during the first years of life but that no change in size in relation to the growth of the posterior cranial cavity occurs throughout the entire growth period This cistern thus develops at the same rate as the posterior cranial cavity

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During the first two years of life the depth of the suprasellar cisterns decreases, while at the same time the depth of the interpeduncular cistern increases, both absolutely and relatively These changes in size coincide with the rapid growth of the cerebral hemispheres and the simultaneous displacement of the central parts of the cerebrum in a dorsal direction The pontine cistern undergoes no change in depth despite the relative dorsal displacement of the aqueduct This is explained by a simultaneous increase in volume of the pons The pontocerebellar cisterns decrease somewhat, both in width and lateral extension after the age of two years A relative increase in the volumes of the cerebellar hemispheres and pons in relation to the posterior cranial cavity may explain the change in size of these cisterns Finally, the cisterna magna follows the growth of the posterior cranial cavity, and its relative size remains unchanged during the growth period

SUMMARY

The changes in size of the pontine interpeduncular and pontocerebellar cisterns as well as the cisterna magna during the growth period in children are analysed and discussed with reference to a normal series of encephalographies

ZUSAMMENFASSUNG

Die Grosseveranderungen der Cisternae pontis interpeduncularis pontocerebellaris und der Cisterna magna wahrend der Wachstumsperiode der Kinder wurden an einer Serie von normalen Encephalographien analysiert und die Resultate werden diskutiert



Fig. 1 A-p. and lateral views at initial left carotid angiography. No evidence of aneurysm, no spasm or displacement of the cerebral arteries. (An oblique view was also obtained but this also failed to show any abnormality.)

down the posterior aspects of both legs. Lumbar puncture revealed bloody cerebrospinal fluid.

The patient was transferred to our hospital on November 29, 1966. No neurologic deficit was observed despite severe headache and stiff neck. The blood pressure was 120/84 mm Hg. Lumbar puncture revealed blood in CSF, opening pressure 340 mm and closing pressure 170 mm H_2O, WBC 100 (55% polys), RBC 43100, sugar 66 mg% and protein 75 mg%.

Left common carotid angiography was performed on his first hospital day (Fig. 1) and no abnormality was observed. The headache subsided, opening pressure of lumbar puncture was 180 mm H_2O but the CSF was still bloody.

Five days later there was a sudden increase in headache followed by a brief loss of consciousness. The blood pressure was 210/130. The physical examination showed only nystagmus but no other focal sign. Lumbar puncture at this time again revealed bloody CSF with an opening pressure of 350 mm and closing pressure of 150 mm H_2O.

Right common carotid angiography on the next day (Fig. 2) showed no abnormality. The patient remained obtunded but responsive for about a week; he then had hemiparesis on the right side.

Left common carotid angiography was carried out (Fig. 3). A large anterior communicating aneurysm with a mild degree of spasm in the proximal portion of the left anterior cerebral artery was revealed. Hypothermia and steroids were started and ten days later clipping of the anterior communicating aneurysm was performed under hypothermia.

Discussion

EPSTEIN in 1953 reported a case of subarachnoid hemorrhage. The aneurysm and the parent vessel failed to fill at cerebral angiography. A small soft tissue

FROM THE NEURORADIOLOGIC SECTION OF THE DEPARTMENT OF RADIOLOGY, NEW YORK UNIVERSITY MEDICAL CENTER, NEW YORK, U S A

THROMBOSIS OF ANEURYSM OF ANTERIOR COMMUNICATING ARTERY

Case report

by

JOSEPH P LIN

The accuracy of the radiologic diagnosis of cerebral aneurysms in cases of sub arachnoid hemorrhage has been stated to be 85 to 96 per cent (1, 18, 26) Failure to demonstrate aneurysms angiographically has been attributed to spasm of the parent vessels, the small size of the aneurysm, technical difficulties, inadequate angiographic examinations, observer s error, or to thrombosis of the aneurysm (6, 8, 13, 14, 15, 17, 19, 20 26, 27, 28) The majority of reports deal with spasm of the parent vessels or inadequate angiographic examinations Although a few authors have reported thrombosis as one of the causes (3, 4, 19, 21 25), the presence of an aneurysm was either demonstrated in surgical or post mortem specimens, or the aneurysm was seen only at the first angiographic examination and could not be demonstrated in subsequent angiograms

In the case now reported upon the aneurysm was not filled at the first angio graphic examinations but was demonstrated at a repeat examination

The patient was a 43 year-old man who had been in good health until four days prior to his admission to hospital He had suddenly developed severe frontal headache and neck pain which was accentuated when moving his head He sub equently had pain radiating

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Fig 3 Left carotid angiography performed 12 days after the first angiographic examination a p and lateral views. There is a large aneurysm at the junction of the communicating artery and the left anterior cerebral artery mild spasm of the proximal portion of the left anterior cerebral artery

anterior communicating artery aneurysm failed to fill at the first angiography with presence of severe spasm of the parent vessel Three weeks later this aneurysm readily filled after the spasm of the parent vessel had subsided

In our case the first left carotid angiogram was obtained four days after the onset of subarachnoid hemorrhage Though it was in the acute stage there was no evidence of spasm displacement of the left intracranial vessels or filling of the aneurysm Frontal lateral and oblique views were obtained and subsequently, right brachial and right carotid angiographies were performed in the hope that these studies would lead to detection of the cause of the subarachnoid hemorrhage Multiple projections with cross compression on the left internal carotid artery and use of the subtraction technique again failed to demonstrate any vascular abnormality In the cross compression study the left anterior cerebral artery was well filled via the anterior communicating artery but no filling of the aneurysm or spasm of the left anterior cerebral artery were noted Two weeks after admission the patient had another episode of subarachnoid hemorrhage and he developed right hemiparesis At this time a repeat examination with left carotid angiography disclosed an aneurysm measuring 7 mm×7 mm×10 mm, at the junction of the anterior communicating and the left anterior cerebral arteries with mild degree of spasm of the proximal portion of the left anterior cerebral artery



Fig 2 Right carotid angiography a p view with cross compression No aneurysm could be detected

lesion in the chiasmatic cistern region was demonstrated by encephalography Necropsy revealed a thrombosed aneurysm at the junction of the anterior communicating and anterior cerebral artery completely blocking its lumen

STERN (1955) also reported a case in which the skull roentgenograms disclosed a fine curvilinear calcification, concave forward and arising upwards from sella turcica Complete blockage of the right intracranial portion of the internal carotid artery distal to the origin of the anterior choroidal artery was demonstrated by angiography Surgical exploration disclosed an aneurysmal mass, measuring 2 5 cm×2 5 cm, located within the Sylvian fissure, and completely filled with thrombus In this case, the author stated that had it not been for the tell tale calcification in the conventional roentgenogram, the true cause of the internal carotid artery occlusion would probably have escaped discovery

In the series of DANDY (1944), there were two cases in which the aneurysms were filled with thrombus in the post mortem examination and one case in which a spontaneous cure of the aneurysm took place by complete filling of the sac with a thrombus DANDY stressed the necessity of injecting both the internal carotid arteries and a vertebral artery before the sac could be demonstrated, and even then all might still have been negative

The failure to demonstrate an aneurysm by angiography is not evidence of absence of an aneurysm It is possible that in a number of cases clotting and organization have led to spontaneous healing of the lesion (2, 12, 22) Aneurysms on small arteries have a tendency to thrombose and the parent vessel is also likely to be involved (23) Some authors (9, 10) have considered that the timing of angiography has played an important role in the false negative cases If angiography was carried out in the acute stage of subarachnoid hemorrhage there would have been a greater frequency of non filling of the aneurysm because of adjacent vasospasm FLETCHER et coll (1959) reported on a case in which the

werden Es wird postuliert da die L ision nicht so klein war dass das Ausbleiben der Kontrastfullung bei der ersten angiographischen Untersuchung durch *Thrombose des Aneurysma* verursacht sei Die verschiedenen Faktoren die die angiographische Darstellung der Aneurysmen hindern konnen, werden diskutiert

RÉSUMÉ

L auteur présente un cas d hemorragie sous arachnoidienne avec anevrysme de l artere communicante anterieure qui n avait pu etre mis en evidence au *cours de l examen angiographique* initial L anevrysme s est rempli de moyen de contraste au cours d un examen angiographique ultérieur En raison des dimensions *modérees de l anevrysme il est possible* que la thrombose de l anevrysme l ait empeché de se remplir lors du premier examen angiographique L auteur examine les *divers facteurs qui peuvent empecher de mettre en* evidence angio raphiquement un anévrysme

REFERENCES

1 AF BJORKESTEN G and HALONEN V Incidence of intracranial vascular lesions in patients with subarachnoid hemorrhage investigated by four vessel angiography J Neurosurg 23 (1965) 29

2 — and TROUPP H Prognosis of subarachnoid hemorrhage A comparison between patients *with verified aneurysms and patients with normal angiograms* J Neurosurg 14 (1957) 434

3 *BLACKWOOD W Vascular disease of the central nervous system Greenfield s neuro*pathology 2nd edition p 71 Williams and Wilkins Baltimore 1963

4 CRAWFORD T Some observations on the pathogenesis and natural history of intracranial aneurysms J Neurol Neurosurg Psychiat 22 (1959) 259

5 DANDY W C *Intracranial arterial aneurysms* Comstock Publishing Company New York 1944

6 ECKER A and RIEMENSCHNEIDER P A Arteriographic demonstration of spasm of the intracranial arteries with special reference to saccular arterial aneurysms J Neurosurg 8 (1951) 660

7 EPSTEIN B S The roentgenographic aspects of thrombosis of aneurysm of the anterior communicating and anterior cerebral arteries Amer J Roentgenol 70 (1953) 211

8 FLETCHER T M TAVERAS J M and POOL J L Cerebral vasospasm in angiography for intracranial aneurysms Incidence and significance in one hundred consecutive angio*grams Arch Neurol 1 (1959) 38*

9 FRENCH L A ZARLING M E and SCHULTZ E A Management of aneurysms of the anterior communicating artery J Neurosurg 19 (1962) 870

10 HAMBY W B The aneurysmal origin of nonfatal subarachnoid hemorrhage an angiographic survey of 53 cases J Neurosurg 10 (1953) 35

11 HAWKES C D and OGLE W S Vasospasm with subarachnoid hemorrhage from intra cranial aneurysm Arch Surg (Chicago) 90 (1965) 404

12 HOOK O Subarachnoid hemorrhage prognosis when angiography reveals no aneurysm A report of 138 cases Acta med scand 162 (1958) 493

In the absence of spasm of the left anterior cerebral artery at the initial angiographic examination, we could not attribute the cause of non filling of the aneurysm to spasm of the parent vessel The angiographic examinations, including bilateral carotid and right brachial angiograms, were adequate and the size of the aneurysm was not too small The explanation for the non filling of the aneurysm seemed to be thrombosis of the aneurysm, as in the cases mentioned by HAMBY (1953) He suggested that repetition of angiography after an interval of time would lead to the demonstration of aneurysms in some cases but he did not give any example in his series "The patho physiological response to the rupture of an aneurysm was for the vessels in continuity with the aneurysm for a varying distance around it to go into intense spasm, and this spasm slowed up, perhaps for a time, even arrested completely the blood flow through the sac, with the resultant relaxation of tension on it, the sac wall could shrink a little, the tear would narrow and become sealed with clot The spastic vessels tended to relax, probably gradually and at different rates in different individuals, and blood under increasing pressure flowed through the sac again If the seal of the clot was strong enough there was no further hemorrhage, if not, it gave way and the whole process was repeated (LOGUE 1956)

It is possible in our case that hemorrhage had occurred from the aneurysm and that it was obliterated by thrombus or a blood clot, wherefore the contrast medium could not enter the aneurysmal sac at the first examination The thrombosed aneurysm ruptured again in the following days and the size of the aneurysmal sac enlarged after each bleed (2, 4, 13) Finally, it reached the stage when thrombus or blood clot could no longer interfere with the entry of contrast medium through the orifice of the aneurysm and the lesion could readily be contrast filled at repeat angiography

SUMMARY

A case of subarachnoid hemorrhage with an anterior communicating artery aneurysm which could not be demonstrated at the initial angiographic examination is reported upon The aneurysm was contrast filled at a later angiographic examination Because of the moderate size of the aneurysm it is postulated that the cause of non filling at the first angiographic examinations may have been due to thrombosis of the aneurysm The various factors that may lead to failure to demonstrate an aneurysm angiographically are discussed

ZUSAMMENFASSUNG

Ein Fall von Subarachnoidalblutung wird beschrieben bei dem ein Aneurysma der Arteria communicans anterior bei der ersten angiographischen Untersuchung nicht entdeckt werden konnte Das Aneurysma konnte bei einer wiederholten Angiographie mit Kontrast gefullt

FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN), SERAFIMERLASARETTET STOCKHOLM, SWEDEN

RADIOGRAPHIC METHOD WITH MINIMAL RADIATION DOSE

by

O MATTSSON

A radiographic method for repeated recording involving the lowest possible radiation dose is needed for special purposes as in follow up examinations of the gastro-intestinal tract. A fairly large part of the body is then usually included in the numerous exposures made during the passage of the meal. This paper presents a method that has been developed to fulfil the requirements for a planned extensive study of barium meals both in healthy subjects under varying conditions and in subjects with digestive disorders.

Several studies of the transit time have been made in conventional follow up examinations as well as by means of the cineradiographic recording of motility. Since the introduction of a low viscosity stabilized barium sulphate suspension (EMBRING & MATTSSON 1963) which can be mixed with different types of nutritive components as well as with ordinary food without much changing its character the interest in studies of the passage time has been increasing.

Insufficient attention appears to have been paid previously to the fact that the conventional barium meal fails to stimulate the gastro-intestinal system consequently no estimation of the transit time under physiologic conditions can be made with this type of meal.

A nutritive meal containing barium was introduced in 1959 (MATTSSON LAGERLOF & PERMAN) for the purpose of studying the passage of the intestinal

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13 JEFFERSON G Compression of the chiasma, optic nerves and optic tracks by intracranial aneurysms Brain 60 (1937) 444
14 LEVY L A Subarachnoid hemorrhage without arteriographic vascular abnormality J Neurosurg 17 (1960), 252
15 LIST C F and HODGES F J Intracranial angiography diagnosis of vascular lesions J Neurosurg 3 (1946) 25
16 LOGUE V Surgery in spontaneous subarachnoid hemorrhage operative treatment of aneurysms on the anterior cerebral and anterior communicating artery Brit Med J 1 (1956) 473
17 MAGLADERY J W On subarachnoid bleeding — an appraisal of treatment J Neurosurg 12 (1955), 437
18 PERRETT L V and BULL J W D The accuracy of radiology in demonstrating ruptured intracranial aneurysms Brit J Radiol 32 (1959) 85
19 PERRETT G and NISHIOKA H Report on the cooperative study of intracranial aneurysms *and subarachnoid hemorrhage Section IV Cerebral angiography an analysis of the* diagnostic value and complications of carotid and vertebral angiography in 5 484 patients J Neurosurg 25 (1966) 98
20 PETTY P G Subarachnoid hemorrhage of undetermined aetiology Med J Aust 2 (1966) 1
21 POOL J L and POTTS D G Aneurysms and arteriovenous anomalies of the brain Harper and Row New York 1965
22 ROBERTSON E G Cerebral lesions due to intracranial aneurysms Brain 72 (1949) 150
23 — ROSS RUSSEL R W Observations on intracranial aneurysms Brain 86 (1963) 425
24 SCHNECK S A and KRICHEFF I I Intracranial aneurysm rupture vasospasm and infarction Arch Neurol 11 (1964) 668
25 STERN W E Mechanisms in the production of hemiparesis associated with intracranial aneurysm Brain 78 (1955) 503
26 SUTTON D and TRICKEY S E Subarachnoid hemorrhage and total cerebral angiography Clin Radiol 32 (1962) 297
27 WALSH L S Subarachnoid hemorrhage Acta radiol 46 (1956) 321
28 WOOD E H Angiographic identification of the ruptured lesion in patients with multiple cerebral aneurysms J Neurosurg 21 (1964) 182



Fig 2 Radiographic equipment with roentgen tube below the table and the rotating lead disc just above it the image intensifier is situated above the table

anatomic localization or transit study can be made in this way The use of so-called endosonds e g small radiotransmitters built into capsules and swallowed does not solve the present problem though they may of course be traced and furnish certain simple chemical or physical data.

Follow up examinations of the alimentary tract have up to now been mainly performed by means of conventional full size roentgen films exposed repeatedly at fixed intervals As the time of passage of the meal varies considerably frequent exposures are needed Since the beginning of the transit time studies the radiation dose has received special attention The number of exposures must be kept at the minimum needed for obtaining satisfactory information and only exceptionally has the examination been repeated on the same patient Yet investigations of this type require an adequate number of films and since it is preferable to use the same subject for studies under varying conditions the question of the radiation dose has been under constant critical observation It should however be kept in mind that such films are not intended essentially for a detailed anatomical study but merely serve to establish the general location of the contrast medium to enable a determination of the transit time In order to keep the radiation dose as low as possible it may therefore be considered permissible to accept a lower image quality than must be demanded from a conventional full size film

From a consideration of existing alternatives it was thought that by employing

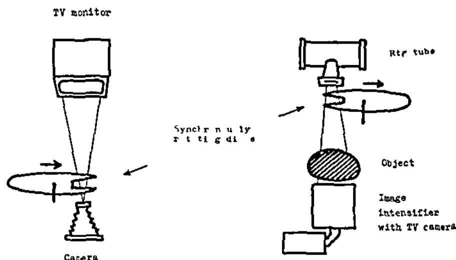


Fig 1 The radiographic system includes a rotating shutter in front of the tube as well as one between the camera and the monitor Both are synchronized and produce exactly one complete scanning for each exposure

contents, especially in different disturbances of nutrition The investigations hitherto made have clearly indicated the influence of the nutritive contents, typical changes were evident in certain pathologic conditions It has also been possible to gather useful information about the normal motility of the gastro-intestinal tract These investigations increased the interest of the present author in the conditions of motility of the alimentary tract under the influence of various internal and external factors

Many questions regarding the transit of food through the gastro intestinal tract remain unanswered The conditions that arise when many small meals are taken, as compared with those prevailing with normal eating or when a few heavy meals are taken, are unknown The patterns of movement arising from different types of diets, or from food containing excessive amounts of e g fat or carbohydrates must be important The effects of fluid taken before, during or after a meal, and in this connection the influence of alcoholic beverages may be of certain interest, and the effects of various drugs given to patients with digestive trouble are well worth knowing Changes due to sedentary life and physical exercise as well as to stress are other important factors

These are only some of the aspects requiring elucidation Many digestive disturbances are of course merely deviations from the normal intestinal activity about which, again, little is known Radiography offers an easy and adequate means of examining the alimentary tract, the tube technique used by physiologists is also of considerable value in the analysis of chemical and enzymatic conditions, which to some extent closely follow intestinal activity but no general



Fig 4 Roentgenogram of the small intestine reproduced from a follow up examination as recorded on the monitor The coarse grain was caused by quantum noise but the image is good enough for its purpose

A Hasselblad type 500 C camera with magazine loading is used for recording the monitor screen image By changing the magazine, two or more patients can be examined at the same time The 2 1/4 by 2 1/4 inch films are well suited for direct viewing Some details of the arrangement are shown in Fig 2 The roentgen tube with the rotating shutter is placed below the examination table

The quality of the image obtained with this radiographic method is very much dependent on the amount of quanta available and an adjustment of the milliamperage must always be made to obtain a suitable compromise An acceptable image can be obtained even at a relatively low milliamperage Synchronization of the camera exposures must be so precise that the shutter is closed except during the period when the scanning takes place electronic noise presented on the monitor screen may otherwise show up and destroy the video signal image

Two films obtained by the system described are reproduced in Figs 3 and 4 The former is a recording from the monitor of a wire mesh it was produced from just one complete scanning and the homogeneity is good A film of the small intestine as recorded from the monitor in a follow up examination is depicted in Fig 4 it has a coarse grain caused by quantum noise but the film is satisfactory for its purpose

Thus instead of using full size roentgenograms for which some 10 mAs are required the milliamperage can be reduced to a range between 0 1 and 1 mA while the time needed for a complete scanning will be less than a tenth of a second Assuming the kilovoltage to be the same in this comparison, the total gain might be of the order of 500 when the recording is made in the manner described It might be mentioned in this connection that the exposure gain with a 70 mm film and an image intensifier directly connected to the output phosphor is generally considered to be about 4 times but it should also be kept in mind that

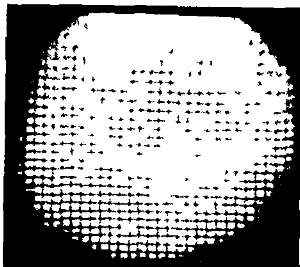


Fig 3 Recording of a wire mesh from the monitor produced from one complete scanning

an image intensifier coupled with a television camera, the television image on the monitor might serve as a basis of documentation and by employing a special technique at the same time offer an effective way of reducing the radiation dose So-called cinescopic recordings have been made in cineradiography, and the recording of the video signal on tape is a well known procedure, but single exposures from the monitor screen do not seem to have been widely used for dose reduction although it is possible to produce quite good results in this way

In the case of stationary objects the image on the monitor corresponds to identical presentations continuously repeated Its information can be fully utilized if a complete scanning is recorded once by a camera The roentgen exposure can then be as short as the time needed to cover one single scanning An experimental device based upon this principle has been developed

In view of the objects to be studied, the abdominal region an intensifying system with a front screen of sufficient size was needed It seemed that the Cinelix image intensifying system combining a 12 1 2 inch screen with an Orthicon tube could be well worth trying out for this purpose The requirements were a synchronized exposure system producing a photographic exposure just sufficient to cover one complete scanning and at the same time functioning as a mechanical shutter for the roentgen rays in order to obtain a suitably short exposure It must be stressed that at low currents because of the considerable delay involved the roentgen exposures cannot be controlled by electrical means The roentgen tube is therefore continuously energized, and the exposure is made with the shutter The synchronized exposure system may be based on the function of syngon elements or precisely adjusted synchronous motors (Fig 1)

FROM THE RADIO DIAGNOSTIC DEPARTMENT AND THE PHYSICS DEPARTMENT OF THE LONDON HOSPITAL, WHITECHAPEL, LONDON, ENGLAND

EVALUATION OF THE NEW CONTRAST MEDIUM UROVISON

by

RONALD B. PRIDIE and S. KLEVENHAGEN

A completely scientific trial of a contrast medium under clinical conditions is not possible except in limited circumstances. All such substances carry a risk, albeit a very low one, of producing toxic complications and the risk increases with the dose. It is not justifiable, therefore, on ethical grounds, to give a second injection, nor is it reasonable to give extra irradiation with the sole object of comparing two densities. Furthermore, subsequent injections of contrast media will not necessarily provide a valid comparison because the first injection affects the vascular bed of the patient. SAKO (1963) showed that most contrast media produce first a transitory increase in resistance to blood flow and then shortly afterwards vasodilation. ROBERTS *et coll.* (1967) have shown that there is a constant drop in systemic blood pressure following angiography with Conray 280. This alteration of the vascular bed results in variation in the rate of flow within the arteries and so variation in the dilution of the contrast material even if the injection rate is constant. The inability to standardise conditions within patients means that *in vitro* comparisons under conditions simulating those found *in vivo* are likely to be more reliable than investigations using either experimental animals or patients.

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a comparison can never be made between the quite different qualities of the radiographic images thus obtained Certain variations of the kilovoltage (high voltage technique) may be of importance and produce favourable values for full size films, although within a comparatively limited range

As a complete examination is estimated to include about 20 exposures, the total dose may only amount to some 5 per cent of the exposure dose for a single conventional full size film This means that safe conditions with respect to exposure dose may be created The experimental results have shown that it is possible to obtain a radiographic image of acceptable quality for the planned studies of transit times and motility The system is not complicated and may be utilized with different types of roentgen equipment

SUMMARY

A means of obtaining roentgenograms with a very low roentgen dose to the patient is described The method involves a considerable reduction in image quality but may be useful for those purposes in which the radiation dose must be particularly considered

ZUSAMMENFASSUNG

Eine Methode wird angegeben die es ermöglicht Röntgenfilme mittels einer minimalen Strahlenbelastung der Patienten zu erzielen Die Methode führt zu einer erheblichen Verminderung der Bildqualität trotzdem ist sie wertvoll wo eine verminderte Strahlenbelastung besonders angebracht ist

RÉSUMÉ

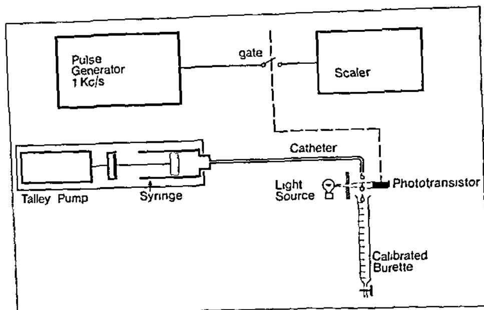
Description d une technique permettant d obtenir des radiographies avec une très faible dose d irradiation du malade Cette méthode implique une diminution considérable de la qualité de l image mais elle peut être utile dans les cas ou on doit tenir particulièrement compte de la dose d irradiation

REFERENCES

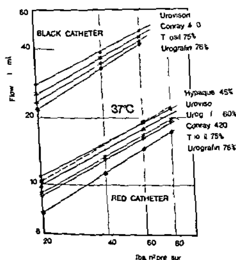
EMBRING G and MATTSSON O Stabilized barium sulphate X ray compositions U S Patent No 3216900 Washington Patent Office November 9th 1965

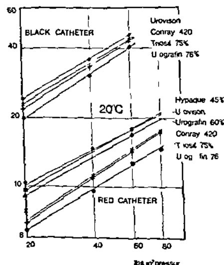
— — An improved physiologic contrast medium for the alimentary tract Acta radiol Diagnosis 4 (1966) 105

MATTSSON O LAGERLÖF H and PERMAN G Barium contrast medium with physiological properties Some experiences Abstr 9th Intern Congr Radiology Munich 1959 p 145



F g 1 Diagram of appa atus used for constructing flow curves





F gs and 3 Graphs of flow rates of contrast med a through wide (black) catheters and narrow (red) catheters at 37 C (left) and 20 C (ight) at different inject on pressures plotted on log log scale

Table

Physical data for different contrast media

	Iodine content mg/ml	Viscosity in centipoise		Specific gravity at	
		20° C	37° C	20° C	37° C
Hypaque 45%	270	5.1	2.9	1.297	1.290
Urografin 60%	290	7.2	4.3	1.325	1.318
Urovison	325	6.1	3.5	1.349	1.345
Urografin 76%	370	16.5	8.5	1.435	1.424
Conray 420	420	8.9	5.4	1.450	1.441
Triosil 75%	440	9.4	5.9	1.450	1.443

In this paper, the physical investigations we have made of the properties of a new contrast medium, Urovison (Schering Chemicals Ltd), are described and the clinical applications of the medium are reported briefly.

Physical properties of Urovison. Each millilitre of Urovison contains 400 mg of the sodium salt of N,N' diacetyl 3,5 diamino 2,4,6 triiodobenzoic acid, 180 mg of the methylglucamine salt of N,N' diacetyl 3,5 diamino 2,4,6 triiodobenzoic acid, and 0.4 mg disodium ethylenediaminetetraacetate (Titriplex III, USP XVII). The viscosity at 37° C is 3.5 centipoise and it contains 325 mg of iodine per millilitre. Comparative figures for Urovison and five other contrast media are given in the Table. The iodine contents were taken from the manufacturers literature, but the values for viscosity and specific gravity were measured, as all the figures were not available from the makers.

Flow curves. The quality of arteriograms varies primarily with the concentration of iodine which is achieved under the circumstances of the examination. To discover how Urovison in this respect compared with other contrast media flow curves were determined for different pressures, using black and red Kifa catheters with internal diameters of 1.96 mm and 1.32 mm respectively.

A major problem in the determination of flow curves is the accurate timing of the duration of flow. Previous investigations (KLEVENHAGEN & NALLWAJSKI 1963, KROVETZ et coll. 1966) have relied on microswitches operated by the moving piston of the pump. Such methods, however, measure the duration of movement of the piston, not the duration of flow, and these are not necessarily the same.

We therefore devised an apparatus, shown diagrammatically in Fig. 1, with which the duration of flow could be measured directly. A photo transistor was placed in a narrow beam of light and the resultant electric current used to hold

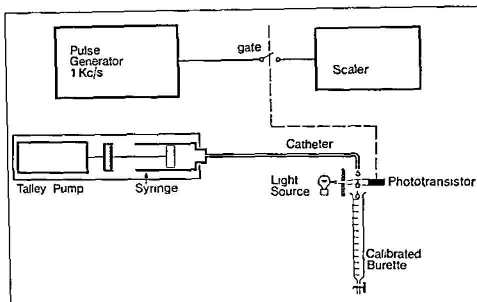
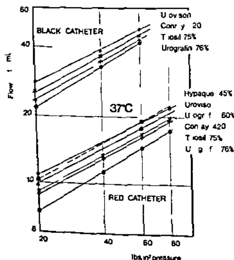
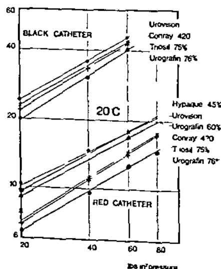


Fig 1 Diagram of apparatus used for constructing flow curves





Figs 2 and 3 Graphs of flow rates of contrast media through wide (black) catheters and narrow (red) catheters at 37 C (left) and 20 C (right) at different injection pressures plotted on log log scale

Table

Physical data for different contrast media

	Iodine content mg/ml	Viscosity in centipoise		Specific gravity at	
		20 C	37 C	20 C	37 C
Hypaque 45	270	5 1	2 9	1 297	1 290
Urografin 60 %	290	7 2	4 3	1 325	1 318
Urovison	325	6 1	3 5	1 349	1 345
Urografin 76 %	370	16 5	8 5	1 435	1 424
Conray 420	420	8 9	5 4	1 450	1 441
Triosil 75	110	9 4	5 9	1 450	1 443

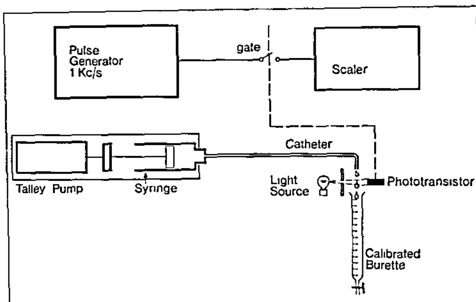
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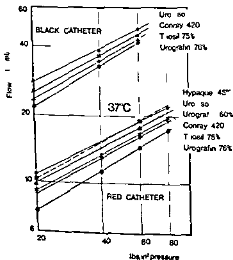
Flow curves The quality of arteriograms varies primarily with the concentration of iodine which is achieved under the circumstances of the examination To discover how Urovison in this respect compared with other contrast media, flow curves were determined for different pressures, using black and red Kifa catheters with internal diameters of 1 96 mm and 1 32 mm, respectively

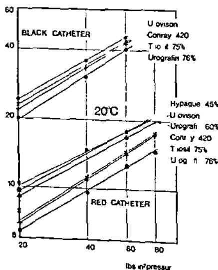
A major problem in the determination of flow curves is the accurate timing of the duration of flow Previous investigations (KLEVENHAGEN & NALEWAJSKI 1963, KROVETZ et coll 1966) have relied on microswitches operated by the moving piston of the pump Such methods, however measure the duration of movement of the piston, not the duration of flow, and these are not necessarily the same

We therefore devised an apparatus, shown diagrammatically in Fig 1, with which the duration of flow could be measured directly A photo transistor was placed in a narrow beam of light and the resultant electric current used to hold



F g 1 D agram of appa atus used for construct ng flow curves





F gs 2 and 3 Graphs of flow rates of contrast media through w de (black) catheters and narrow (red) cathet rs at 37 C (left) and 20 C (right) at d fferent njection pressures plotted on log log scale

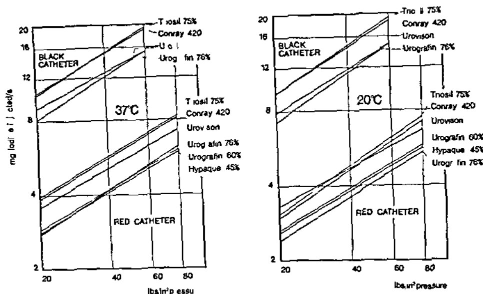
open a gate between a pulse generator and a pulse counting scaler The photo sensitive device was mounted below the open end of a catheter and above a burette

The contrast medium to be tested was first opacified with one drop of ink to each 100 ml of fluid and then drawn into a 50 ml Sommerville syringe, connected to a catheter 100 cm in length, and ejected by means of a Talley pump When the fluid flowed out of the catheter, the light was obscured, the gate closed and the pulses which resulted were counted on the scaler The pulse frequency was 1 000 per second, so that the duration of the ejection was recorded in milliseconds with an accuracy of $\pm$ 5 milliseconds All the fluid was collected in a burette and the quantity passed was measured It was thus possible to construct a graph of the flow rates when different pressures were applied to the Talley pump The pressure was read on the gauge attached to the pump In addition, a special thermostatically controlled electric blanket was constructed for the Sommerville syringe, so that the temperature of the contrast medium could be varied

Flow rate and iodine injection rate The flow rates for Urovison, Conray, Triosil, Urografin and Hypaque for red and black catheters at 37° C and 20° C are shown in Figs 2 and 3 The curve of flow rate plotted against pressure gives a straight line when charted on a log log scale It can be seen that the flow rate of Urovison is greater than that of any of the other contrast media, at both room and body temperatures, for both sizes of catheter and for the whole range of pressures studied, with the single exception of Hypaque 45 % in narrow catheters at high pressure

The delivery rate of a contrast medium is not however the only index of its efficacy from the radiologic point of view The radio density depends essentially on its iodine content and hence the amount of iodine which is injected per second should also be determined Graphs of the iodine injection rates in mg/s, plotted against the injecting pressures were derived from the flow rate curves by multiplying the ordinates by the iodine content per millilitre of the contrast medium, as given in the Table The resulting graphs are shown in Figs 4 and 5

When wide bore tubing is used (black catheter) the higher concentration of iodine in Conray 420 and Triosil 75 % gives rise to higher iodine injection rates for these media than for Urovison, in spite of the fact that the flow rate of the latter is the greatest This was so at both 20 ° and 37° C The iodine injection rate of Urografin 76 % is however lower than that of Urovison at both temperatures The effect of warming the contrast medium is relatively small when a wide bore catheter is used



F gs 4 and 5 Injection rates of contrast media at various injecting pressures at 37 C (left) and at 20 C (right) plotted on log log scale

With narrow (red) catheters the enhancement of the flow rates by warming was greater for Triosil 75 % and Conrav 420 than for Urovison so that at 37 both gave higher iodine delivery rates than Urovison whatever the pressure At room temperature however the maximum iodine delivery rate was achieved with Urovison when injected at hand pressure i e below 1 45 kg/cm² (20 lbs/sq inch)

Application of physical properties to clinical practice

A practical division of intra arterial injections into two groups can be made according to the volume of the chamber or vessel into which the injection is being made

When the contrast medium is being injected into a large capacity chamber as in angiocardiography or aortography with the catheter situated above the renal arteries the practical effect is to dilute the iodine containing compound with the blood already present Hence the higher the iodine delivery rate the greater will be the density of the contrast medium on the subsequent roentgeno

open a gate between a pulse generator and a pulse counting scaler The photo sensitive device was mounted below the open end of a catheter and above a burette

The contrast medium to be tested was first opacified with one drop of ink to each 100 ml of fluid and then drawn into a 50 ml Sommerville syringe, connected to a catheter 100 cm in length, and ejected by means of a Talley pump When the fluid flowed out of the catheter, the light was obscured, the gate closed and the pulses which resulted were counted on the scaler The pulse frequency was 1 000 per second, so that the duration of the ejection was recorded in milliseconds with an accuracy of ± 5 milliseconds All the fluid was collected in a burette and the quantity passed was measured It was thus possible to construct a graph of the flow rates when different pressures were applied to the Talley pump The pressure was read on the gauge attached to the pump In addition, a special thermostatically controlled electric blanket was constructed for the Sommerville-syringe, so that the temperature of the contrast medium could be varied

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angiography so it was considered to be unjustified to use Urovison for this purpose even though the haemodynamic situation is similar

The urographic examination is quite different and none of the above arguments apply The precise conditions of volume flow and injection rate at the point of injection are irrelevant All that counts (at least to a first *approximation*) is the total amount of iodine injected Even here clinical experience (see below) indicates that there is considerable latitude

Clinical experience

Over 350 patients have now been examined with Urovison and the conclusions obtained from the flow curves and the chemical composition have been borne out In all cases undergoing peripheral arteriography by the translumbar route or by femoral catheterisation or cannulation satisfactory contrast *has been obtained Good contrast* has also been obtained in all cases of selective renal, mesenteric and coeliac angiography

Typical arteriograms made with Urovison are shown in Figs 6 and 7 The first shows the popliteal artery filled with contrast medium by translumbar injection of 35 ml Urovison The second illustration is of a renal artery contrast filled by injection of 7 ml Urovison into a red Kifa catheter, the tip of which is in the origin of the renal artery

In a few cases where Urovison was used for aortography using a catheter with the tip above L1, the films obtained were less satisfactory from the point *of view of contrast than those customarily achieved with the more concentrated* media using similar pressures

In order to test the efficiency of Urovison in urography, alternate patients undergoing this examination were injected with 25 ml Urovison (i e one standard ampoule) or 40 ml Hypaque 45 % (i e two standard ampoules) The total iodine content was 8 1 g and 10 8 g respectively Films were obtained without the use of compression and were assessed by a single observer who did not know which contrast medium had been used *The density of the* contrast medium in the pelves and calyces was graded good bad or indifferent For both *groups 75 % had good contrast density and* similar proportions had less satisfactory contrast This suggests that 25 ml Urovison is comparable in opacifying power to 40 ml of Hypaque 45 %

It is concluded that Urovison is satisfactory for urography but has no overriding advantage over the other products It is easier to inject than the more concentrated media because of its physical properties and relatively less is required for the same degree of contrast as compared with the more dilute range



Fig 6



Fig 7 Selective renal arteriogram obtained after one injection of 7 ml Urovison at hand pressure

Fig 6 (left) Peripheral arteriogram of the common femoral artery and branches following the injection of 35 ml Urovison into the lower aorta by a translumbar needle

grams Therefore, reference to Figs 4 and 5 will show that when a large catheter is used, one of the more concentrated contrast media, such as Triosil 75 % or Conray 420, will give the best results

When, however, injections are being made into small vessels or into branches of the aorta, or even into the distal part of the aorta peripheral to the renal arteries, the rapid efflux of contrast medium from the catheter produces a bolus which displaces the blood The more rapidly the contrast medium can be delivered, the more likely is it that bolus formation will occur that the blood in the vessel will be displaced completely, and that streaming will be avoided The highest flow rates were obtained with Urovison (Figs 2 and 3) which we therefore consider preferable for peripheral and selective angiography CHASE & KRICHEFF (1965) and FISCHER & CORNELL (1965) have demonstrated the superior safety of methylglucamine salts over the sodium salts in cerebral

REFERENCES

CHASE N E and KRICHEFF I I The comparison of the complication rates of meglumine iothalamate and sodium diatrizoate in cerebral angiography Amer J Roentgenol 95 (1965) 852

FISCHER H W and CORNELL S H The toxicity of the sodium and methylglucamine salts of diatrizoate iothalamate and metrizoate Radiology 85 (1965) 1013

KLEVENHAGEN S and NALEWAJSKI W An automatic syringe for rapid injection of contrast media Polish Rev Radiol & Nuc Med 28 (1963) 581

KROVETZ L J FAIRCHILD B T HARDIN S and MITCHELL B Analysis of factors determining delivery rates of liquids through cardiac catheters Radiology 86 (1966) 123

ROBERTS P N YOUNG I P and WINDSOR C W O Hypotension after angiography Lancet *1967 I* p *985*

SAKO Y Haemodynamic changes during arteriography J A M A 183 (1963) 253

Toxicity In the urography series, two patients of each group complained of nausea and three of the Urovison group felt hot There were no other untoward reactions In arteriographic work, one patient developed a rash within twenty minutes but this cleared within 24 hours No other toxic manifestation has been noted in over 350 examinations, most of which have been performed under general anaesthesia

Acknowledgements

We wish to thank Dr R S Murray and Dr M Cohen for their help with critical comment and advice Dr Murray also assessed the I V P s The assistance of Dr Brian Worthington and Dr Martin Molloy who performed many of the arteriographic examinations with Miss V Brodie and the Radiographers of The London Hospital and of Sister Ingham and Miss E Grindley who did the I V P s is gratefully acknowledged The help of Dr Pitchford and Mr Ravid of Schering Chemicals Ltd who donated the Urovison is also acknowledged

SUMMARY

In vitro flow studies have indicated that Urovison from the point of view of flow characteristics is the most satisfactory of the products tested (Conray Triosil Urografin Hypaque) for use in angiography when the contrast medium is being injected into vessels of small calibre as well as in peripheral arteriography For angiocardiography and aortography the more concentrated contrast media are better These conclusions have been confirmed by clinical use of the media

ZUSAMMENFASSUNG

Fluss Studien in vitro haben daruf hingewiesen dass die Flussigkeitscharakteristika von Urovison in Angiographie und auch in peripherer Arteriographie gewisse Vorteile gegenuber den gepruften Mitteln (Conray Triosil Urografin Hypaque) erbietet wenn das Kontrastmittel in kleinkalibrigen Gefassen injiziert werden soll Fur Angiokardiographie und Aortographie sind Kontrastmittel mit hoherer Konzentration besser geeignet Diese Schlussfolgerungen wurden bei der klinischen Anwendung bestatigt

RÉSUMÉ

Une étude du débit in vitro a montré que l Urovison est au point de vue de ses caractéristiques hydrodynamiques le plus satisfaisant des produits experimentés (Conray Triosil Urografin Hypaque) pour l usage angiographique quand le moyen de contraste est injecté dans des vaisseaux de petit calibre ainsi que pour l artériographie périphérique Pour l angio cardiographie et l aortographie les moyens de contraste plus concentrés sont préférables Ces conclusions ont été confirmées par l usage clinique de ces produits

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Symptoms and signs

by

Bo Jacobsson, Sven Paulin and David Schlossman

Percutaneous catheterisation is now widely used especially in diagnostic roentgenology It would appear from the literature, however that arterial catheterisation involves the risk of tromboembolism (Mandelbaum & Schumacker Jr 1962 Lang 1963 McGraw 1963 Halpern 1964 Kottke et coll 1964 Greenstone et coll 1965 Bergentz et coll 1966, Seidenberg & Hurwitt 1966 Mortensen 1967)

The term thromboembolism is used by the authors to denote occlusion of an artery by an embolus or by an obstructive thrombus Thromboembolism is a serious complication and may sometimes even necessitate amputation of the affected limb (Luke & McGraw 1963 Seidenberg & Hurwitt) The figures given for the frequency of thromboembolism following catheterisation of the femoral artery vary between 0 2 % (Saur 1964) and 8 % (Kottke et coll), the corresponding range for amputation being 1 364 (McGraw) to 6 11402 (Lang) According to most investigators thrombi occur more often than emboli

From Roentgen Department I (Director Prof O Bartley) Sahlgrenska sjukhuset, Gothenburg Sweden. Submitted for publication 24 September 1968

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Donizetti P Shadow and substances The story of medical radiology Pergamon Press Oxford 1967

Dux A Koronarographie — Methodik Indikation und Ergebnisse Georg Thieme Verlag Stuttgart 1967

Fochem K Einfuhrung in die geburtshilfliche und gynakologische Rontgendiagnostik Georg Thieme Verlag Stuttgart 1967

Howard N Mediastinal obstruction in lung cancer Livingstone Edinburgh 1967

Instrumentation in nuclear medicine Volume 1 Edited by G J Hine Academic Press New York 1967

John D H O Radiographic processing in medicine and industry Focal Press London 1967

Lacroix L Diagnostica pneumoradiografica in medicina interna Il Pensiero Scientifico Roma 1967

Lalli A F Essentials of urography Charles C Thomas Springfield Illinois 1967

Rogers A W Techniques of autoradiography Elsevier Publishing Co Amsterdam 1967

Talairach J Szikla G Tournoux P et coll Atlas d anatomie stéréotaxique du télencéphale Etude anatomo radiologique Masson & Cie Paris 1967

Turano L Trattato di radiodiagnostica Volume 2 Tomo 2 Fegato e vie biliari vie pancreatiche apparato urogenitale pneumoperitoneo addome acuto Unione Tipografico Editrice Torinese Torino 1967

Ter Pogossian M M The physical aspects of diagnostic radiology Hoeber Medical Division Harper & Row Publishers New York Evanston and London 1967

Tritium labeled molecules in biology and medicine Edited by L E Feinendegen Academic Press New York and London 1967

Waubke T N Fernseh Rontgen intraokularer Fremdkorper Ferdinand Enke Verlag Stuttgart 1967

(The) Year book of nuclear medicine Volume 2 Edited by J L Quinn Year Book Medical Publishers Chicago 1967

Zsebok Z B Einfuhrung in die Methodik der Rontgenuntersuchungen Georg Thieme Verlag Stuttgart 1967

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VAN VOORTHUISEN (1967), however, found the latter complication to be more common

The discrepancies between the frequencies reported for thromboembolism may be explained by differences in diagnostic criteria, in the composition of the series studied, and in the examination technique used The dependence of the frequency of *thromboembolism on the composition of the clinical material* and the examination technique used is the subject of an article to follow (JACOBSSON & SCHLOSSMAN) The present paper deals with an investigation of, first, the reliability of the conventional clinical diagnosis of thromboembolism from the symptoms and physical signs and, secondly, the value of supplementary oscillography A consecutive series of patients studied roentgenographically with percutaneous catheterisation of the femoral artery were examined for complicating *thromboembolism*

Method and Clinical material Oscillography was performed with Gesenius Keller s oscillograph One sphygmomanometer cuff is wrapped tightly around the section of the limb to be studied and another around the corresponding segment of the limb of the opposite side (Fig 1) The cuffs are then inflated to a level above systolic pressure, after which the pressure is reduced in steps until the *recording pulse waves become maximal This occurs when the pressure in* the cuffs is equal to that of the mean blood pressure The arterial pulsations are transmitted by two direct writing levers, each has a terminal ink well and a nib that marks graph paper fed at a rate of 3 5 mm/second This method thus gives simultaneous bilateral registration of the arterial pulsations in the segment of the limb to be examined (HILLESTAD 1962)

With a cuff fitted around the largest circumference of each calf bilateral recordings were made on two occasions, viz before catheterisation and after the release of arterial compression, as a rule, recordings were also made during the compression This was to check that the artery was not occluded for a long time which might increase the risk of thrombosis (VIRCHOW 1856)

The bilateral oscillographic records obtained after catheterisation were compared When the amplitude of the waves on the punctured side was more than half of that on the other side, catheterisation was said to have been without complications When a substantial difference between the two sides existed before catheterisation, the amplitude of the waves on the catheterised side was compared with that before catheterisation, and a reduction by less than half was taken as a sign that thromboembolism had not occurred Repeated measurements were made of the thigh *and of the lower leg for up to 2 hours in the other* patients The reduction was only transient in many patients although fourteen in all had oscillographic differences persisting for more than 2 hours In most of these

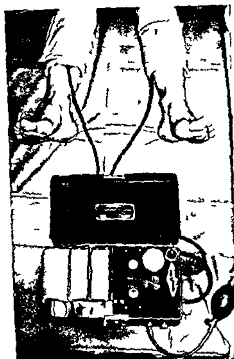


Fig 1 Oscillography performed according to Gesenius-Keller

fourteen patients signs of ischaemia were recorded e g pain, changes in the temperature and colour of the skin and diminution or loss of palpable pulsations on the catheterised side

The primary material consisted of a consecutive series of 880 patients examined on some occasion between 1 September 1965 and 10 October 1967 Most of the examinations consisted of abdominal aortographies the remainder of thoracic studies such as angiocardiography and coronary angiography In order to attain complete agreement with the material of a further investigation (JACOBSSON & SCHLOSSMAN) patients examined with coronary angiography after 1 January 1967 have not been included The femoral artery was always catheterised percutaneously by the SELDINGER method after local anaesthesia with 0 5 % Carbocain® The catheters varied with the type of examination to be performed The fourteen patients with persistent oscillographic changes were selected for further study

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Fig 2 Case 1 Thrombosis of left external iliac artery after retrograde angiocardiography of left ventricle

Fig 3 Case 4 Thrombosis of left superficial femoral artery after coeliacography

Fig 4 Case 3 Thrombosis of right superficial femoral artery after coeliacography

The vessel was occluded in seven and obstructed in the remaining three patients (Cases 3 4 and 10)

Both control angiography and operation were performed on the same day as primary catheterisation except in one patient (Case 7), who was not subjected to control angiography until a month later because the clinical findings did not indicate immediate treatment

The symptoms were mild None of the ten patients had severe pain and only three had moderate aching pain and a local sensation of coldness The lower leg was colder or paler or both in four of six patients whose record sheets contained notes allowing such a comparison Peripheral pulsations were palpated in seven and differences between the two sides were found in five patients

Case 10 with emboli in the fibular artery and anterior tibial artery just below their origin had only oscillographic changes and no other symptoms or signs.

In the remaining four of the fourteen patients the amplitude of the pulsations in the lower leg was 20 to 30 % of that on the opposite side Since these patients

Table

Survey of findings in fourteen patients with thromboembolism after percutaneous catheterisation of the femoral artery

Case No	Sex	Age in yrs	Oscillography*		Angiography	Operation	Thrombosis	Embolism	Subjective symptoms	Signs**	Pulsations
			Thigh	Lower leg							
1	f	54	100	100	+	+	+	—	—	?	?
2	m	25	?	80	—	+	+	—	+	?	+
3	m	70	70	80	+	+	+	—	—	?	+
4	m	58	80	80	+	+	+	—	—	?	?
5	f	45	80	90	—	+	+	—	—	+	—
6	m	17	100	100	—	+	+	+	+	+	+
7	m	48	60	100	+	—	+	+	+	+	+
8	f	35	0	50	—	+	—	+	—	+	?
9	m	47	0	60	+	+	—	+	—	—	+
10	m	61	0	50	+	—	—	+	—	—	—
11	m	59	20	80	—	—			—	—	—
12	f	47	0	50	—	—			—	—	?
13	f	76	20	80	—	—			—	?	?
14	m	54	?	80	—	—			—	+	?

* Reduction in per cent of pulsation on catheterised side

** Determined difference between the two sides regarding colour and temperature of skin

Definition of symbols yes + no — not noted in the records ?

Results

Oscillographic and clinical findings in all the fourteen cases are summarized in the Table Cases 1 to 10 were studied further with control angiography (two), explorative surgery (four) or both angiography and surgery (four) Thromboembolism was demonstrated in all these ten patients, who will be described first

The amplitude of the pulsations in the lower leg was 0 to 50 % of the amplitude on the opposite side The pulsations in the thigh were recorded in nine patients, in six of whom the amplitude was 0 to 40 % of the one in the other leg All the patients in whom the size of the pulsations was reduced both in the thigh and in the lower leg had thrombosis, and two of them had embolism as well The three patients (Cases 8, 9 and 10) with normal pulsations in the thigh had embolism only The thrombi were located near the site of puncture and the emboli in the popliteal artery (four) or just below its bifurcation (one)



Fig 6 Case 10 Embolism of the fibular artery and the anterior tibial artery after coeliacography



Fig 7 Case 7 Embolism of the right popliteal artery after coronary angiography Filling of the anterior tibial artery and the fibular artery through collateral circulation

before the present investigation was started a 43 year old woman developed trombosis of the femoral artery following angiography Since no early symptoms or signs of ischaemia had been noticed the patient was not operated upon until about 30 hours later It proved necessary to amputate the leg probably due in part to this delay

The consequences of underestimating the frequently vague symptoms of thromboembolism may also be exemplified by our Case 7 Oscillography after catheterisation showed reduction of the pulsations in the thigh as well as in the lower leg The patient had only insignificant symptoms and consequently no attempt was made to discover the cause of the reduction It was not until one month later when the patient returned complaining of symptoms of claudication in the previously punctured leg that control angiography was performed The examination revealed occlusion of the deep femoral and popliteal arteries The patient was one of the first in the material and the delay must be ascribed to the fact that at that time the reliability of oscillography in the diagnosis of such complications was not realized

Reports of thromboembolism following catheterisation often contain no details as to how the patients were examined for complications immediately after withdrawal of the catheter (LANG SAUR) but other reports state that the arterial pulsations were palpated routinely (KOTTKE et coll MORTENSEN, VAN VOORTHUISEN) The frequency of thromboembolism in the former group was much lower (0 2 to 0 4 %) than in the latter (1 3 % to 8 %) In 25 patients in whom the brachial artery was catheterised during an operation on the chest *BJÖRK et coll* (1965) performed arteriography before withdrawal of the catheter and

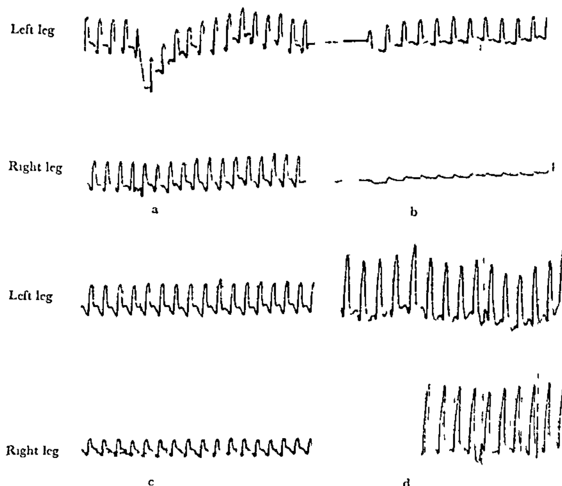


Fig 5 Case 10 Oscillographic recordings of the lower leg before (a) immediately after coeliacography (b) and 3 hours later (c) Oscillographic recording of the thigh immediately after the examination is shown in (d)

were in a poor general condition and had no signs of severe ischaemia neither surgery nor further investigation was contemplated The record sheets of three of these patients contained notes on the oscillographic findings in the thigh, which were described as normal It is clear from the Table that the symptoms and signs were less common in these four patients than in the ten patients with verified thromboembolism

Discussion

Undue delay in the diagnosis and proper treatment of thromboembolism can be disastrous (KEY 1922) That lack of knowledge of the clinical picture may have serious consequences may be exemplified by the following case One year

KINZLMEIER et coll (1957) analysed the error of the method of oscillography performed by two examiners with *Gesenius-Keller s apparatus* and found the S D of the differences on the two sides to vary by 11 5 and 23 5 %, respectively

A post catheterisation reduction of the amplitude of the pulsation in the affected leg to at least 50 % of the *amplitude on the opposite side* was taken as evidence of thromboembolism Such a large difference as 50 % was decided upon for two reasons First *the apparatus had not been* previously tried out in the department Secondly the apparatus was to be used by a relatively large number of examiners However, to determine the error of method, the following control study was subsequently performed Eight volunteers aged 20 to 40 years without known vascular disease were represented Pressure cuffs were wrapped around *the lower legs and two of us recorded* the pulsations three times each at short intervals with replacement of the cuffs Each examiner noted all the values independently of the other

Statistical analysis of the values noted disclosed no significant differences between the recordings or the reading of values by the two examiners The error of method amounted to 1 56 mm between the two sides irrespective of the amplitude of the waves so it proved more suitable to measure the absolute than the relative difference between the sides

A difference of 2 54 mm between the sides was significant ($p < 0.05$) provided the waves on both sides were equal before catheterisation Comparison between repeated recordings made on the same side put the error of method to 1 57 mm and a difference of 2 57 mm was thus significant This implies that a difference in amplitude of the oscillographic recordings can be demonstrated by *comparison with the original value on the side studied There is thus a possibility* of evaluation in the event of a difference in size of the oscillographic waves between the two sides before catheterisation provided of course that the blood pressure is the same as before the examination

Considering the fact that the method never gave a false positive diagnosis and the results of the above statistical analysis it would seem possible to obtain *better* results by modifying the oscillographic criteria. The use of the oscillographic method revealed that catheterisation of the femoral artery in 985 patients was *followed by* arterial occlusion in fourteen patients Ten of these were afterwards subjected to control angiography or explorative surgery which confirmed the diagnosis *of thromboembolism in all of them* It may thus be assumed that the remaining four patients also had thromboembolism All the fourteen patients are discussed below as a single group

Many of the patients had *no symptoms or signs of* ischaemia such as changes in the temperature and colour of the skin (see Table) This is in agreement with the findings in MORTENSEN s clinical material in which twenty of the forty



Fig 8 Case 9 Embolism of the right popliteal artery after coronary angiography

recorded the pulsations oscillographically after the catheter had been withdrawn Occlusion was seen in fourteen of the patients and in all of these the oscillographic recordings also presented distinct abnormalities

These reports indicate differences in the diagnostic criteria used by the investigators referred to above

The discrepancies between the reported frequencies of thromboembolism may also be explained in part by differences in the composition of the clinical material and in the examination technique The possible effect of these differences will be discussed in the next article (JACOBSSON & SCHLOSSMAN)

The diagnosis of acute arterial occlusion may be based on symptoms and signs and on the objective recording of arterial pulsations or of the blood flow Verification of the diagnosis requires angiography or explorative surgery The apparatus necessary for recording the blood flow is still too expensive and complicated to be recommended for routine control examination after arterial catheterisation In an attempt to find a uniform but simple method we have tried to supplement conventional clinical examination by oscillography It would appear that this combination has not been attempted before on a large series following arterial catheterisation

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patients with arterial occlusion presented no evidence of ischaemia. One of the patients with occlusion of the femoral artery had no symptoms at all. A patient with such asymptomatic occlusion has also been reported by MANDELBAUM & SCHUMACKER. A palpatory decrease in the strength of the arterial pulsations was the most reliable sign of thromboembolism. In three patients no certain difference could be felt between the sides: two of these (Cases 10 and 11) had no symptoms at all, while the temperature of the skin of the lower leg of the third patient was somewhat low. BJORK et coll. have also described patients with angiographically verified arterial occlusion without any definite palpable decrease in the amplitude of pulsations. In the present investigation the patients had not been examined for other signs of arterial occlusion, such as reduced capillary blood flow and venous filling.

All patients with oscillographic changes satisfying the definition on page 98, subjected to control angiography or explorative surgery, proved to have thromboembolism. This means that there were no false positive diagnoses. On the other hand, there is no proof that thromboembolism would have been detected more frequently if a smaller difference factor between the sides had been used, although even with the large difference used, the oscillographic control of the pulsations revealed some cases of thromboembolism that might otherwise not have been detected.

Transient oscillographic reduction in the size of the waves observed in some patients was presumably due to vascular spasm.

When the pulsations were reduced only in the lower leg, the reduction was always due to embolism of the popliteal artery or of the initial segment of one of its branches. This technique thus appears to locate the level of the occlusion with a fair degree of accuracy. Of the four patients not afterwards subjected to angiography or explorative surgery and in whom the thromboembolism was thus not verified, three most likely had embolism because the pulsations were reduced only in the lower leg. The ratio between the frequency of thrombosis and embolism in the present series was roughly 1 : 1 and thus about the same as that in VAN VOORTHUISEN's but differed from the figures given by KOTTKE et coll. and by LANG, who reported a ratio of 3 : 1. Other authors have published only single cases. Since the symptoms of embolism appear to be milder than those of thrombosis (see Table, p. 100) embolism is more apt to escape detection.

The observations made in the present investigation indicate that physical symptoms and signs of thromboembolism after catheterisation of the femoral artery are often slight and may sometimes be absent altogether. Oscillography has proved to be a valuable diagnostic method and can probably be improved by refinement of the oscillographic procedure.

SUMMARY

The reliability of the conventional clinical examination and the value of supplementary oscillography in the early diagnosis of thromboembolism following percutaneous catheterisation of the femoral artery for angiography is assessed with reference to 14 complicated cases

ZUSAMMENFASSUNG

Thromboembolische Komplikationen nach perkutaner Katheterisierung der Femoralarterie wurden bei 14 Fallen festgestellt Die Zuverlässlichkeit der gewohnlichen klinischen Untersuchungsmethoden wird diskutiert und der Wert zusätzlicher Oscillographie als Mittel der Fruhdiagnose in solchen Fallen wird hervorgehoben

RÉSUMÉ

En se basant sur 14 cas de complications les auteurs examinent la valeur de l examen clinique habituel et de l examen oscillographique dans le diagnostic précoce des thromboembolies apres cathétérisme percutane de l artere femorale pour angiographie

REFERENCES

BERGENTZ S E HANSSON L O and NORBACK B Surgical management of complications to arterial puncture Ann Surg 164 (1966) 1021

BJORK L ENGHOFF F GRENVIK Å et coll Local circulatory changes following brachial artery catheterization Vasc Dis 2 (1965) 283

CREENSTONE S M MASSELL T B and HERINGMAN E C Hazards and complications of retrograde aortography and arteriography Angiology 16 (1965) 93

HALPERN M Percutaneous transfemoral arteriography An analysis of the complications in 1 000 consecutive cases Amer J Roentgenol 92 (1964) 935

HILLESTAD L K The peripheral blood flow in intermittent claudication III The significance of oscillometry Acta med scand 172 (1962) 573

JACOBSSON B and SCHLOSSMAN D Thromboembolism of leg following percutaneous catheterisation of femoral artery for angiography Predisposing factors Acta radiol Diagnosis 8 (1969) 109

KEY E Embolectomy for embolic disturbances Acta chir scand 54 (1922) 339

KINZLMEIER H WOLF F und ENGEHAUSEN G Quantitative Auswertenmoglichkeit des Oscillogramms nach Gesenius-Keller Ärztl Wschr 26 (1957) 565

KOTTKE B A FAIRBAIRN J F and DAVIS G D Complications of aortography Circulation 30 (1964) 843

LANG E K A survey of the complications of percutaneous retrograde arteriography Seldinger technic Radiology 81 (1963) 257

LUKE J C and McGRAW J Y Complications following catheter angiography Arch Surg 86 (1963) 414

MANDELBAUM I and SCHUMACKER JR H B Percutaneous arterial catheterization Arterial complications Arch Surg 85 (1962) 889

McGRAW J Y Arteriography of peripheral vessels A review with report of complications Angiology 14 (1963) 306

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MANDELBAUM I and SCHUMACKER JR H B Percutaneous arterial catheterization Arterial complications Arch Surg 85 (1962) 889

MCGRAW J Y Arteriography of peripheral vessels A review with report of complications Angiology 14 (1963) 06

MORTENSEN J D Clinical sequelae from arterial needle puncture, cannulation and incision Circulation 35 (1967) 1118

SAUR H Th Ein Überblick uber die Komplikationen bei der indirekten (perkutanen Katheter) Methode der Aortographie Z Kreisl Forsch 53 (1964) 314

SEIDENBERG B and HURWITT E S Retrograde femoral (Seldinger) aortography surgical complications in 26 cases Ann Surg 163 (1966), 221

SELDINGER S I Catheter replacement of the needle in percutaneous arteriography A new technique Acta radiol 39 (1953) 368

VIRCHOW R Gesammelte Abhandlungen zur wissenschaftlichen Medicin p 219 Medinger Sohn Frankfurt 1856

VAN VOORTHUISEN E A Ervaringen met selectieve arteriografie van de arteria coeliaca en de arteria mesenterica superior Stafleu s Wetenschappelijke Uitheversmaatschappij Leiden 1967

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THROMBOEMBOLISM OF LEG FOLLOWING PERCUTANEOUS CATHETERISATION OF FEMORAL ARTERY FOR ANGIOGRAPHY

Predisposing factors

by

Bo JACOBSSON and DAVID SCHLOSSMAN

Several reports of thromboembolism following percutaneous catheterisation of the femoral artery have been published The frequency of the complication varies from one series to another SALR (1964) for example reported 0 2 % while KOTTKE et coll (1964) gave a figure as high as 8 % Such discrepancies are probably due to differences in the criteria used in the diagnosis of the condition in the examination technique and in the composition of the clinical material

The complication often produces only vague symptoms and is therefore readily missed Even palpation of the pulse is not always conclusive These difficulties in the diagnosis of thromboembolism following catheterisation of the femoral artery was the subject of the preceding article in this journal In many investigations into the cause of the complication interest has been focused on the examination technique and only secondarily on the condition of the patient

As to the performance of the examination the following details have been stressed as important puncture technique (HALPERN 1964) the length of the catheter and the volume of contrast medium used (KOTTKE et coll) duration

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of the examination (LUKE & MCGRAW 1963, BJORCK et coll 1965, GREENSTONE et coll 1965) and degree of arterial compression after the examination (LUKE & MCGRAW, HALPERN, FOGERTY & KRIPPAEHNE 1965, SEIDENBERG & HURWITT 1966) As to the condition of the patient, advanced age (LANG 1963), atherosclerosis (LUKE & MCGRAW, GREENSTONE et coll), heart disease (LANG, HALPERN) and arterial spasm (LUKE & MCGRAW, HALPERN) are believed to increase the risk of thromboembolism following catheterisation

Though several factors have been pointed out as contributory causes of thromboembolism, it has not been possible to assess their relative importance or to prove any particular one to be the main culprit It was therefore considered legitimate to try to find out whether any one or more factors are predominantly responsible for the development of thromboembolism following percutaneous catheterisation of the femoral artery

Material and Methods The material consisted of 880 consecutive angiographies performed with percutaneous catheterisation of the femoral artery by the SELDINGER (1953) method and covered a 2 year period (1 September 1965 — 10 October 1967) The material consisted in the main of abdominal arteriographies and to some extent of thoracic examinations, including coronary angiographies Coronary angiographies performed after 31 December 1966 were not accepted because from then and onwards a modified technique was used

The arterial pulse in the lower leg was examined oscillographically before and after examination of the vessels (JACOBSSON et coll 1969) The material was classified according to the type of examination Technical data such as length and type of catheter, average duration of the examination, volume and type of contrast medium the patient s age and the number of examinations in each group are given in Table 1 This classification divided the material roughly into different groups of disease

Coronary angiography, usually because of coronary disease was performed according to the method described by PAULIN (1964), i e with a catheter having a spiral tip Other thoracic examinations, including retrograde catheterisation of the left ventricle and examinations with the tip of the catheter placed in the ascending aorta, were performed with a catheter provided with side holes and with the end hole occluded by a metal knob fastened to the end of a metal wire These techniques were employed in the investigation of organic heart disease and stenosis of the aortic arch and its branches Only radiopaque, grey polythene catheters (Kifa) were used for thoracic examinations

The examination technique employed for coeliacography was the same as that for mesenteric angiography In the presentation of the material and results, these two types of angiography have therefore been grouped together, and are hence

Table 1

Examination methods and technical data pertaining to the entire material

Angiographic examination	Data on the catheter			Volume of contrast medium ml	Mean age of patients	Mean catheter time minutes	Number of	
	Type	O D mm	Length cm				Angiographies	Thromboembolism
Coronary angiography	Kifa grey	2.8	80	80—90	45	42	76	6
Thoracic aortography	Kifa grey	2.8	70	40—80	49	53	63	4
Coeliac angiography	Kifa yellow Kifa green	2.8 2.4	40	80—100	62	67	69 37	4 0
Nephroangiography	Teflon*	2.2	30	40—80	52	46	506	0
Femoral arteriography	Teflon	2.2	25	80—100	57	55	120	0

In 85 cases aortography was supplemented by selective nephroangiography (Kifa green)

forth referred to under the common name of coeliacography. Both the coeliac artery and the superior mesenteric artery were catheterised in the examination of the liver and the pancreas. The chief indication for this examination was possible malignant disease. The superior as well as the inferior mesenteric artery were catheterised in intestinal diseases, usually inflammatory. Of the 106 examinations belonging to this group, a radiopaque yellow polythene catheter (Kifa) was used in 67 and a green one in 39 instances.

Nephroangiographies and angiographies of the pelvis and the leg were performed with a teflon catheter with side holes and an occluded tip. In the former group the tip of the catheter was placed in the aorta at the level of the origin of the renal artery and in the latter immediately above the aortic bifurcation. Nephroangiography was supplemented in 85 cases by selective nephroangiography with a radiopaque green polythene catheter (Kifa). The commonest indications for nephroangiography were an expanding process, hypertension and inflammatory renal changes and, for angiography of the pelvis and the leg, obliterating diseases of the vessels.

The puncture technique and the technical performance of arterial compression after the examination were uniform throughout the period covered by the investigation. The puncture site was anaesthetised with about 10 ml carbocaine 0.5% (Carbocain®). General anaesthesia was never used and on no occasion

Table 2

Data on the patients in whom catheterisation was followed by thromboembolism

Age	Sex	Type of angiography	Catheterisation time in minutes	Symptoms Diagnoses
17	m	Coronary	60	Murmur
47	m		30	Adam Stokes disease
47	f		60	Scleroderma arrhythmia
25	m		45	Friedreich s ataxia
48	m		65	Hypercholesterolaemia
54	m		45	Angina pectoris
59	m	Thoracic aortography	60	LV aneurysm
35	f		45	Organic heart defect
54	f		45	Organic heart defect
45	f		60	Organic heart defect
76	f	Coeliac	80	Hypernephroma
70	m		60	Pancreatic cancer
61	m		80	Pancreatic cancer
58	m		45	Hepatic cancer

was any drug injected through the catheter Urografin and Isopaque were employed randomly for each type of examination, each in two concentrations Urografin in concentrations of 290 and 370 mg iodine/ml and Isopaque in concentrations of 260 and 370 mg iodine ml The higher concentrations were used for thoracic examinations the lower ones usually for the abdominal investigations All angiographies of the coronary vessels and most of the other thoracic aortographies were performed by one or the other of two roentgenologists with long experience of angiography Other angiographies were performed by in all some ten roentgenologists, less experienced than the two mentioned above

After these prospective studies the case records of 275 patients were studied *retrospectively for any correlation between thromboembolism* and malignant tumours or heart disease (including congenital or acquired organic cardiac defects, myocardial infarction arrhythmias cardiac incompensation, roentgenologically demonstrated heart size exceeding 600 ml/m) Noted was also the presence, if any, of roentgenologically demonstrated disease of the coronary vessels Sufficient case records from each type of investigation were studied to allow calculation to be made of the total number of patients with the above diseases

in each group i e the records of 50 patients subjected to coronary angiography, 50 to thoracic aortography, 50 to coeliacography, 75 to nephroangiography and 50 to angiography of the pelvis and the leg

Results

Fourteen thromboemboli were diagnosed their distribution among the various types of examination being given in Table 1 data on the patients with this complication are presented in Table 2

Table 1 indicates that complications occurred after coronary angiography thoracic aortography and coeliac angiography although not following nephroangiography or angiography *of the pelvis and leg The former group of* examinations will hereinafter be referred to as the complicated group the latter as the uncomplicated group

Clinical material The ages of the patients who developed thromboembolism after anyone of the above types of angiography did not differ from the others examined by the same method Nor did the patients in the complicated group differ *significantly in age from those in the uncomplicated group*

Retrospective analysis of the case records revealed heart disease in 50 % of those examined by coronary angiography and in 65 % of those subjected to *thoracic aortography Four of the six patients who developed thromboembolism* after the former type of examination had heart disease as had four in whom the complication occurred after the latter type of examination Of the patients subjected to coeliacography with a yellow radiopaque polythene catheter 70 % had malignant growths four patients who developed thromboembolism after this type *of examination had some malignant disease* The total number of patients with heart disease was larger in the uncomplicated group than in the complicated group (95 and 80 respectively) a corresponding difference was also recorded for malignant diseases (75 and 55 respectively)

Coronary angiography revealed changes in 50 % of the patients examined *with this method* Three of the six patients who developed thromboembolism after the examination had no roentgenographically demonstrable changes in the coronary vessels.

Examination technique The patients who developed complications after a given type of examination did not differ from the others *regarding the duration* of the examination type or volume of contrast medium used and compression technique Neither was there any essential difference in these respects between the complicated and uncomplicated groups

The site of puncture was normal in appearance in five of the six patients

subjected to operation, in the sixth there was a moderate tear in the artery In none of the patients in whom complications occurred was the catheter changed during the examination

The complicated and uncomplicated groups differed as regards the catheters used In the former group the catheter was at least 40 cm long, its outer diameter was 2 8 mm and it was made of radiopaque polythene (Kifa) In the uncomplicated group, the catheter was shorter (less than 40 cm), its outer diameter smaller (2 2 to 2 4 mm) and it was made of teflon — except for nephroangiography in which a radiopaque green polythene catheter (Kifa) was sometimes also used (in 85 of 506 examinations) All the cases of thromboembolism after coeliacography occurred among the 69 patients who were examined with a yellow polythene catheter while none was recorded among the 37 patients examined with the thinner green catheter of the same material

Discussion

Complications following arterial catheterisation by the Seldinger method have often been reported Some radiologists are therefore reluctant to use this procedure and claim that the translumbar technique is the method of choice for abdominal aortography (BEALL JR et coll 1963, MCGRAW 1963) Percutaneous catheterisation offers, however, such important advantages as to be indispensable It was therefore considered necessary to discover the factor or factors responsible for the complications and find means of preventing them

Thromboembolism is widely believed to be the commonest serious complication (LANG, KOTTKE et coll) Factors described as favouring this sequela were mentioned in the introduction It is not possible to assess the relative importance of such predisposing factors from the literature owing to incomplete description of diagnostic criteria or of the clinical material Many examiners believe that advanced age and heart disease or vascular disease are predisposing conditions For example, HALPERN stated that experience suggests that thrombosis may be primarily a problem in the cardiac group of patients , and LANG concluded that this is true above all for patients with low output failure

In our assessment of the importance of heart disease the term is to be understood as comprising congenital or acquired organic heart defects, myocardial infarction, arrhythmias, cardiac incompensation and enlargement of the heart and thus presumably tallies with the conceptions of previous workers in this field Most patients with thromboembolism after coronary angiography and all those with such a complication after thoracic aortography had heart disease but of the patients examined with coronary angiography or thoracic aortography as many as 50 % and 65 %, respectively, had heart disease Moreover, since most of the

patients with heart disease belonged to the uncomplicated group there is no reason to assume any causal relationship between heart disease and thromboembolism The fact that most of the complications in HALPERN s and LANG s series occurred in patients with such disease is not sufficient by itself to warrant the conclusion that the condition predisposes to thromboembolism after catheterisation

LANG and LUKE & MCGRAW postulated that atherosclerosis predisposes to thromboembolism following catheterisation No attempt was made to estimate the overall incidence of atherosclerosis in the present material The fact that demonstrable peripheral vascular disease among those patients who developed thromboembolism was uncommon and that no angiographies of the pelvis and the leg — performed mainly because of obliterating arterial disease — were followed by complications argues against atherosclerosis playing any substantial role in the causation of complications after catheterisation Supervention of arterial occlusion after catheterisation in these patients is however difficult to diagnose because the circulation is impaired with the blood flowing mainly through collaterals already before the examination

Judging from the angiograms coronary atherosclerosis does not appear to be a predisposing factor either thromboembolism occurring equally often in the presence as in the absence of atherosclerosis

Vascular spasm was not recorded systematically In view of the ages of the patients with complications vascular spasm could hardly have been a major causal factor since it occurs mainly among young individuals (WICKBOM & BARTLEY 1957)

The above observations argue against the general assumption that advanced age heart disease atherosclerosis and vascular spasm are of major importance in the causation of thromboembolism after catheterisation

A factor that may perhaps be of aetiologic significance and one not discussed in the angiographic literature is an increased tendency to thrombosis This is known to occur particularly after operation (MURPHY & MUSTARD 1962, OWREN 1963) and in the presence of malignant tumours (CRANE 1957 GROSS 1960) of certain infections (OWREN) of cardiac incompensation (CRANE, MORRELL et coll 1963) and of congenital and acquired organic heart defects (GROSS)

Many of the patients of the material had heart disease or malignancy but since these conditions mostly occurred in the uncomplicated group neither can be regarded as predisposing factors All the patients who developed thromboembolism after coeliacography had malignant tumours but nor does this warrant any conclusion because 70 % of the patients subjected to coeliacography with a yellow radiopaque polythene catheter had malignant disease

According to OWREN there is strong evidence that changes in the actual com

position of the blood may predispose to thrombotic complications. Changes of relevant importance are, above all, increased adhesiveness of the platelets and aggregation of the platelets (OWREN, NILSSON 1966), both presumably capable of increasing the risk of thrombosis following catheterisation. JACOBSSON (1969), however, could find no significant difference in platelet adhesiveness between patients subjected to coronary angiography and those examined with nephroangiography or angiography of the pelvis or leg, i.e. the examinations with the highest and lowest frequency of complications.

The frequency of thromboembolism did not vary with such technical data as puncture technique, duration of examination, compression technique or volume and type of contrast medium.

The uncomplicated and complicated groups differed however essentially from one another as regards length and diameter of the catheter, and often also in *regard to the material from which the catheter was made. In the complicated* group the catheter was 2.8 mm in diameter, at least 40 cm long and made of radiopaque polythene, while in the uncomplicated group it was 2.2 to 2.4 mm in diameter, less than 40 cm long, and in most cases made of teflon. These data, however, do not suggest which of these differences was of the greatest importance.

Eighty-five selective nephroangiographies were performed with catheters formed of the same material as those in the complicated group, and none were followed by complications. The only technical difference between the examination of these eighty-five angiographies and that of the complicated group was that the catheters used in the former were shorter and of smaller diameter, and thereby had a smaller surface. The frequency of complicating thromboembolism was significantly lower after the use of the smaller catheter. The coeliacographies (106 examinations) were performed with two types of catheter differing from one another only in diameter. All the complications (four) occurred among the 69 patients catheterised with the larger catheter. This suggests that the use of the thinner catheter is less risky.

No teflon catheters of the same diameter as the polythene catheters used in the complicated group were employed. It is therefore not possible to say anything about the importance of the material of which the catheters are made.

As in MCGRAW's and SEIDENBERG & HURWITT's series, thrombosis was more common after thoracic than after abdominal aortography. These authors did not, however, ascribe this to differences in length of the catheters used. KOTTKE et coll. found thoracic examinations to be more risky and felt that this was due to differences in volume and type of the contrast medium used and to the length of the catheter, but they made no attempt to find out which of these factors was the most important.

The observations made in the present investigation appear to warrant the con

clusion that it is above all the catheter that is the major cause of thromboembolism after percutaneous catheterisation of the femoral artery Other technical details may occasionally play a contributory role but are as a rule, of only subordinate importance

SUMMARY

The risk of thromboembolism of the leg following percutaneous catheterisation of the femoral artery for angiography appears to vary mainly with the length and thickness of the catheter as well as possibly also with the type of material of which it is made Other technical factors and the general condition of the patient are apparently of less importance

ZUSAMMENFASSUNG

Das Risiko eines thromboembolischen Zwischenfalles im Bein nach perkutaner Katheterisierung der Femoralarterie scheint in der Hauptsache von der Lange und der Dicke des *Katheters abhangig zu sein, moglicherweise* auch von der Art des Materiales des Katheters Andere technische Faktoren und der Gesamtzustand des Patienten scheinen von geringerer Wichtigkeit zu sein

RÉSUMÉ

Le danger de thrombo-embolie du membre inferieur apres catheterisme percutane de l artere fémorale pour angiographie parait dependre surtout de la longeur et du diametre du catheter ainsi que peut etre du type de matiere dont il est fait Les autres facteurs techniques et l etat général du sujet ont apparamment moins d importance

REFERENCES

BEALL JR A C HENLY W S MORRIS JR G C et coll Translumbar aortography A simple safe technic Ann Surg 157 (1963) 887

BJORK L ENGHOFF E GRENVIK Å et coll Local circulatory changes following brachial artery catheterization Vasc Dis 2 (1965) 283

CRANE C Deep venous thrombosis and pulmonary embolism New Engl J Med 257 (1957) 147

FOGARTY T J and KRIPPAEHNE W W *Vascular occlusion following* arterial catheterization *Surg Gynec Obstet 121 (1965) 1295*

GREENSTONE S M MASSELL T B and HERINGMAN E C Hazards and complications of retrograde aortography and arteriography Angiology 16 (1965) 93

GROSS K Die thromboembolischen Erkrankungen Friedrich Karl Schattauer Verlag Stuttgart 1960

HALPERN M Percutaneous transfemoral arteriography An analysis of the complications in 1 000 consecutive cases Amer J Roentgenol 92 (1964) 935

JACOBSSON B Effect of vascular catheterisation on platelet adhesiveness To be published in Europ Soc Exp Surg
— PAULIN S and SCHLOSSMAN D Thromboembolism of leg following percutaneous catheterisation of femoral artery for arteriography Symptoms and signs Acta radiol Diagnosis 8 (1969) 97
KOTTKE B A FAIRBAIRN J F and DAVIS G D Complications of aortography Circulation 30 (1964) 843
LANG E K A survey of the complications of percutaneous retrograde arteriography Seldinger technic Radiology 81 (1963), 257
LUKE J C and McGRAW J Y Complications following catheter angiography Arch Surg 86 (1963) 414
McGRAW J Y Arteriography of peripheral vessels A review with report of complications Angiology 14 (1963) 306
MORRELL M T TRUELOVE S C and BARR A Pulmonary embolism Brit med J 1963 II p 830
MURPHY E A and MUSTARD J F Coagulation tests and platelet economy in atherosclerotic and control subjects Circulation 25 (1962) 114
NILSSON I M The development of thrombosis p 191 Thule International Symposia on Stroke Nordiska Bokhandelns Forlag Stockholm 1967
OWREN P A Coronary thrombosis Its mechanism and possible prevention by linolenic acid Ann intern Med 63 (1965) 167
PAULIN S Coronary angiography A technical anatomic and clinical study Acta radiol (1964) Suppl No 233
SAUR H Th Ein Überblick uber die Komplikationen bei der indirekten (perkutanen Katheter) Methode der Aortographie Z Kreisl Forsch 53 (1964) 314
SEIDENBERG B and HURWITT E S Retrograde femoral (Seldinger) aortography Surgical complications in 26 cases Ann Surg 163 (1966) 221
SELDINGER S I Catheter replacement of the needle in percutaneous arteriography A new technique Acta radiol 39 (1953) 368
WICKBOM I and BARTLEY O Arterial spasm in peripheral arteriography using the catheter method Acta radiol 47 (1957) 433

FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF J FRIMANN DAHL) AND SURGICAL DEPARTMENT III (DIRECTOR PROF F BERGAN), ULLEVAL HOSPITAL, OSLO NORWAY

ANGIOGRAPHY IN ACUTE PANCREATITIS

by

TRYGVE AAKHUS MIKAL HOFSLI and EINAR VESTAD

Pathologic enlargement of the pancreas and the liberation of vasoactive substances in acute pancreatitis may be expected to produce characteristic features in the angiograms. BOIJSEN & OLIN (1964) reported slight hypervascularity in the pancreas and displacement of the pancreatic arteries ROSCH (1966) found enlarged and numerous arterial branches with enlargement of the pancreatic head in one case SAMMONS et coll (1967) held that the increased number, tortuosity and size of the arteries together with the greater volume of the pancreas and displacement of the arteries were characteristic of acute pancreatitis these authors also observed increased capillary contrast filling with irregularity and mottling as well as early arteriovenous shunting It would appear however that no evaluation of the diagnostic yield of the angiographic findings in this condition has been published

Angiography has been performed as a necessary precursory examination to the *intra arterial treatment of acute pancreatitis with the* proteinase inhibitor Trasylol recently started at this hospital (VESTAD & AAKHUS 1968) Fifteen of the cases were subjected to follow up angiography after the acute condition had subsided Angiograms of the acute phase were compared with the follow up

Submitted for publication 22 August 1968



Fig 1 Acute pancreatitis Selective coeliac angiography Arterial phase in a p projections acute stage (upper) and follow up 8 months later (lower) Comparison reveals increased diameters of the hepatic gastro duodenal and pancreatic arteries in the acute stage the number and calibre of the small arterial branches in the liver are markedly increased but those in the pancreas only slightly The coeliac common hepatic splenic and gastroduodenal arteries are slightly displaced

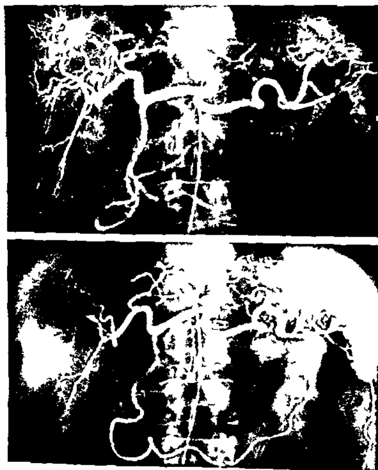


Fig 2 Acute pancreatitis Selective coeliac angiography Arterial phase in a p projections acute stage (upper) and follow up 4 weeks later (lower) The changes are the same as seen in fig 1 In this case also dilatation of the splenic and left gastric arteries occurred in the acute stage

angiograms to decide if characteristic appearances were associated with the acute stage

Material and Method The material consists of 8 males and 7 females ranging in age between 41 and 83 years The diagnosis of acute pancreatitis was based on characteristic histories and clinical findings and a urinary amylase level of 1 024 Wohlgemuth units or more

Conventional films of the abdomen in fourteen of the cases showed peritoneal



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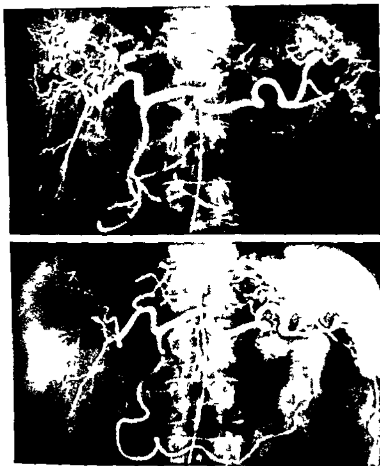


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Fig 3 Acute pancreatitis Selective coeliac angiography Arterial phase lateral projections acute stage (a) and follow up angiography 2 weeks later (b) Swelling in the pancreatic region (arrows) and raised diaphragm in the acute stage the coeliac artery appears raised

irritation in ten In three of these, soft tissue density referable to pancreatic swelling or local oedema was observed between the stomach and the transverse colon In four cases, no changes were demonstrated

Serial selective angiography of the coeliac artery was performed in all cases Superior mesenteric angiography was also carried out in those cases in which the main arterial supply to the pancreas appeared to be shared by this artery Follow up angiography was usually performed 2 to 3 months later For coeliacography, 35 ml Isopaque 60 % were used and for angiography of the superior mesenteric artery 25 ml, injection at a rate of 10 ml/second in all the examinations The course and calibre of the large vessels were evaluated and the size number and course of the smaller vessels in the organs were carefully noted The angiograms were routinely obtained in a p projections Occasionally, a lateral series was also obtained In some instances in the follow up series, two injections of contrast medium were given successively to evaluate the effect of the contrast medium on the vessel calibres The films were obtained at one second intervals for 10 seconds This period was sufficient to cover all phases with the low

viscosity Isopaque but the film series permitted only a rough evaluation of the flow velocity of the medium in the various arteries.

Results

Arterial phase (Figs 1 2 and 3) Displacement of the major branches which could possibly be referred to a swelling of the pancreas was noted in seven cases. In these cases the coeliac the common hepatic and the splenic arteries appeared to be raised and the gastroduodenal artery pushed to the right It was noted, however that a difference in the depth of inspiration could cause a considerable change in the course of the arteries. It was found that the diaphragm appeared more elevated in acute pancreatitis than at follow up in six of these seven cases

In the remaining eight cases no noticeable change in the course of the major arteries seemed to have taken place The course of the pancreatic arteries did not appear to be significantly altered in acute pancreatitis. The diameters of the major arterial branches are presented in Fig 4 as the mean of three measurements A definite increase was noted in the hepatic arteries in most of the cases although sometimes no notable change or only a slight decrease was apparent The gastroduodenal artery was also often enlarged while only arbitrary changes seemed to occur in the left gastric and splenic arteries. The dorsal pancreatic artery was adequate for exact comparison in five cases only definite dilatation was evident The number and size of the small vessels of the liver pancreas and spleen were assessed in cases adequate for comparison and are tabulated below

	Liver	Pancreas	Spleen
Increased	11	11	0
Unchanged	4	2	8
Reduced	0	0	3
Total	15	13	11

Unequivocally increased vascularity was usually present in the liver and the pancreas in acute pancreatitis on the whole the hypervascularity was more marked in the liver Unchanged or slightly reduced vascularity was noted in the pleen No definite change in the course of the minor branches in the organs was observed

Parenchymatous and enous phases In these phases no consistent changes were apparent in acute pancreatitis A slight variation in contrast density of the pancreas in the parenchymatous phase seemed to be completely arbitrary Significant displacement or compression of the splenic or portal veins was not demonstrated

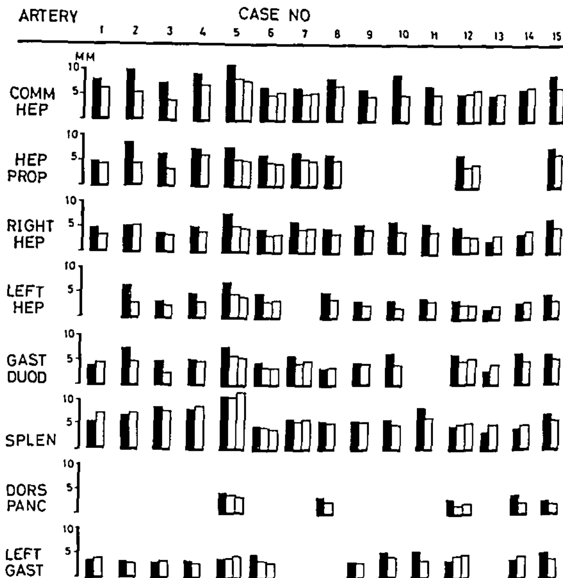


Fig 4 Record of arterial diameters measured in the angiograms the values are the means of three measurements Black columns represent the arterial diameters in acute pancreatitis white columns the follow up diameters In the follow up examinations of Cases 5 6 7 and 12 two injections were given The diameters of the hepatic arteries were usually markedly increased in the acute stage and the dorsal pancreatic artery slightly dilated some dilatation of the gastroduodenal artery was also often noted while an arbitrary variation of the calibre of the left gastric and splenic arteries seemed to occur

Arterial blood flow The method permitted only a rough evaluation of the flow velocity based on the transit time of the contrast medium, within this limitation *no definite change in the velocity of flow was noted in the arteries* in acute pancreatitis An increase in the volume flow apparently thus took place in the dilated arteries and was particularly marked in those supplying the liver

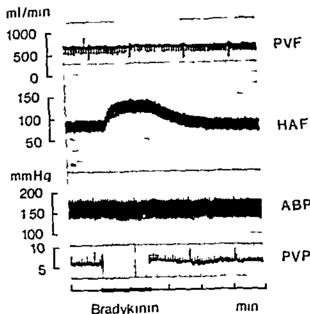


Fig 5 Experimental study of the influence on the hepatic circulation of intraportal injection of bradykinin in the pig Injection of 10 µg of bradykinin diluted in 0 ml saline into the portal vein failed to affect the portal venous flow or the arterial blood pressure A marked rise in the hepatic arterial flow occurred PVF — portal venous flow HAF — hepatic arterial flow ABP — arterial blood pressure PVP — portal venous pressure (Courtesy of AUNE et coll.)

Discussion

Enlargement of the pancreas associated with acute inflammation may cause displacement of the surrounding arteries A change in the course of these arteries may however also be attributed to elevation of the diaphragm, as evidenced in the present material

A variety of vasoactive substances are produced in acute pancreatitis (HOLLENBERG et coll 1962) as was demonstrated in the blood in experimental and human pancreatitis by KATZ et coll (1964) The activated proteinases trypsin and kallikrein pathologically released are known to liberate the polypeptides bradykinin and kallidin respectively from the plasma α 2 globulin (LEWIS 1960 ROCHA E SILVA 1960 WERLE 1960) These polypeptides possess potent vasodilating and hypotensive properties and provoke edema by increasing the permeability of the capillaries (WERLE 1963) The vasodilating substance histamine

is also released from pancreatic tissue by trypsin (BERNARD et coll 1958) It may be assumed that these substances are present in the inflammatory exudate in and around the pancreas in acute pancreatitis and exert a dilatory action directly upon its vessels

Furthermore, these substances are likely to be transported by the portal venous system and produce edema and vasodilatation in the liver Marked changes in the liver were demonstrated histologically in experimental studies of acute pancreatitis by HANSSON et coll (1961) and ANDERSSON (1966) It is also known that impairment of the liver function may occur in cases of acute pancreatitis (FISHER & McCLOY 1955, WEINSTEIN et coll 1963, FREIDEN 1965) The alteration of the vascularization of the liver noted in the present study may reasonably be referred to vasodilatation produced by these polypeptides BOIJSEN & REDMAN (1966) demonstrated a marked increase in the velocity of flow in the hepatic arteries following the intra arterial injection of bradykinin, and in some instances an increased calibre of the arteries was noted

In preliminary experimental studies in the pig AUNE et coll (1968) found that bradykinin injected into the portal vein increased the hepatic arterial flow markedly, while the portal venous flow was unaffected (Fig 5) This may reasonably be explained by a marked reduction in resistance of all vessels in the liver Such an effect will increase the hepatic arterial flow but leave the portal flow unchanged, the latter is essentially determined by the resistance in the organs drained into the portal vein, i e the spleen stomach, bowel, and the pancreas It is generally accepted that a decreased peripheral resistance with increased flow results in a dilatation of the corresponding arteries

Acute pancreatitis is often associated with grave disturbances of electrolyte and fluid balance, and furthermore the effect of vasoactive substances on the peripheral vascular resistance in the body may contribute to the shock that occurs in some cases Shock affects the circulation through the liver (MULLER & SMITH 1961, 1963 FRANK et coll 1962) and vasoconstriction may possibly be expected in the hepatic arteries in some instances However, no definite explanation was found for the reduced calibre of the hepatic vessels in two of the present cases. Both these had normal blood pressures and only slight signs of hypovolemia as judged from the hematocrit and hemoglobin values

The present angiographic findings can hardly be explained as normal variations in the same case The localization of the changes in certain vascular areas suggests that factors associated with acute pancreatitis are involved The same argument may be held against other factors, such as catheterization procedures contrast medium, injection pressure and the pulse pressure that may influence arterial calibre Some apparent dilatation may be referred to geometric enlargement caused by anterior displacement of arteries due to swelling of the gland

(Fig 3) Within reasonable limits of pancreatic swelling however, this will probably result in only slight arterial enlargement.

The absolute and relative size of the various branches of the coeliac artery as well as their course normally vary considerably from one subject to another The present angiographic findings although referable to *acute pancreatitis, could* thus not be detected without the follow up angiograms. It must therefore be concluded that this study was unable to reveal angiographic signs of definite diagnostic value in acute pancreatitis

SUMMARY

Angiograms obtained in 15 cases of acute pancreatitis were compared with those obtained after the acute stage had subsided An increase in the diameters of the hepatic and pancreatic arteries and hypervascularity of the liver and pancreas were usually observed in the acute condition The pathologic mechanism and the diagnostic significance of the angiographic findings are briefly discussed

ZUSAMMENFASSUNG

Angiographie wurde in funfzehn Fällen von akuter Pankreatitis vorgenommen und die Erscheinungen wurden mit denen verglichen die in Angiogrammen nach dem Abklingen der akuten Phase demonstriert wurden Allmahlich wurde in der akuten Phase eine Erhohung der Diameter der Leber und Pankreas Arterien sowie Hypervascularization der Leber und des Pankreas observiert Der pathologische Mechanismus und die diagnostische Signifikanz der angiographischen Befunde werden kurz diskutiert

RÉSUMÉ

Des angiographies faites dans 15 cas de pancreatite aigue ont éte comparees avec les angiographies faites apres le stade aigu Habituellement au stade aigu les auteurs ont constate augmentation du diametre des arteres hépatiques et pancreatiques et d hypervascularisation du foie et du pancreas Ils examinent brievement le mecanisme pathologique et la *valeur diagnostique des aspects angiographiques*

REFERENCES

ANDERSON MARION C Hepatic morphology and function Alterations associated with acute pancreatitis Arch surg 92 (1966) 664

AUNE S RAEDER M and LIE M Hepatic blood flow measured by electromagnetic flow meter and hydrogen clearance To be published in Scand J Gastroenterol

BERNARD A DE LATTRE A et LAMELIN P Le role de la trypsine dans la pancreatite aigue Arch Mal Appar d g 47 (1958) 507

BOIJSEN E und OLIN T Zoliakographie und Angiographie der Arteria mesenterica superior *In* Ergebnisse der medizinischen Strahlenforschung Neue Folge, Band I, S 112—142 Georg Thieme Verlag Stuttgart 1964

— and REDMAN HELEN C Effect of bradykinin on celiac and superior mesenteric angiography Invest Radiol 1 (1966), 422

FISHER E R and McCLOY D Hepatic lesions of acute hemorrhagic pancreatitis Surgery 37 (1955) 217

FRANK E D FRANK H A, JACOB S W and FINE F Hepatic blood flow in experimental hemorrhagic shock Amer J Physiol 202 (1962) 7

FREIDEN J H Significance of jaundice in acute pancreatitis Arch Surg 90 (1965) 422

HANSSON K LUNDH G and STENRAM O Morphological and secretory studies in experimentally induced pancreatitis in rats Acta chir scand 121 (1961) 274

HOLLENBERG M KOBALD E E PRUETT R and THAL A P Occurrence of circulating vasoactive substances in human and experimental pancreatitis Surg Forum 13 (1962) 302

KATZ W SILVERSTEIN M KOBOLD E E and THAL A P Trypsin release kinin production and shock relationship in experimental and human pancreatitis Arch Surg 89 (1964) 322

LEWIS G P Active polypeptides derived from plasma protein Physiol Rev 40 (1960) 647

MULLER W and SMITH L L Changes in the hepatic circulation with graded hemorrhage retransfusion and blood volume overexpansion An experimental study in the dog Surg Forum 12 (1961) 73

— — Hepatic circulatory changes following endotoxin shock in the dog Amer J Physiol 204 (1963) 641

ROCHA E SILVA M Biochemistry and pharmacology of bradykinin *In* Polypeptides which affect smooth muscles and blood vessels p 210 Edit by M Schachter Pergamon Press New York 1960

ROSCH J Angiographie du pancreas Ann Radiol 9 (1966) 579

SAMMONS B P NEAL JR M P ARMSTRONG JR R H and HAGER H G Ten years experience with celiac and upper abdominal superior mesenteric arteriography Amer J Roentgenol 101 (1967) 345

VESTAD E and AAKHUS T Acute pancreatitis Intraarterial treatment with Trasylol To be published in Acta chir scand

WEINSTEIN B R KORN R J and ZIMMERMANN H J Obstructive jaundice as complication of pancreatitis Ann intern med 58 (1963) 245

WERLE E Kallikrein kallidin and related substances *In* Polypeptides which affect smooth muscle and blood vessels p 199 Edit by M Schachter Pergamon Press New York 1960

— Plasma Kinine Munch med Wschr 50 (1963) 2486

FROM THE ROENTGEN DEPARTMENTS OF ST ERIKS SJUKHUS (DIRECTOR S E SJÖGREN) AND SERAFIMERLASARETTET (DIRECTOR PROF ERIK LINDGREN) STOCKHOLM, SWEDEN

EPINEPHRO PHLEBOGRAPHY OF BENIGN TUMOURS

by

C G MIKAELSSON

Endochrinologic disturbances are often caused by adrenal neoplasms which may be either malignant or benign Malignant tumours are as a rule the autonomous producers of hormones but also benign adenomas may act in this way The benign new growths are generally 10 to 30 mm in width when detected, but even a 3 mm tumour may give rise to primary aldosteronism with severe hypertension Adenomas are usually less vascularized than the malignant growths and more difficult to detect with conventional radiologic methods

Catheterization of the left adrenal vein was described by BUCHT in 1962 and was used also for retrograde phlebography In 1964 BUCHT et coll demonstrated an aldosteronoma with this technique Epinephro-phlebography of the right adrenal gland as well was described in a preliminary report to the Nordic Radiologic Congress at Oslo in 1966 and this work was subsequently published (MIKAELSSON 1967) Since then a modification of the technique for catheterization of the left side has been introduced and two small aldosteronomas have been demonstrated (MIKAELSSON 1968) Three papers by other authors have appeared since 1967 REUTER et coll (1967) demonstrated three adrenal tumours, 30 mm in width in a series of 45 cases SUTTON (1968) described seven adrenal tumours, detected with phlebography of the left adrenal vein in 26 cases MELBY et coll (1967) determined the correct side of the adrenal tumour by analysis of the

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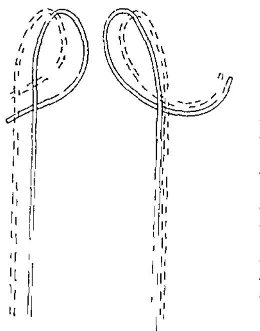


Fig 1 Polythene catheters for the adrenal veins extremities of size being marked out with continuous and dotted lines For the right adrenal gland the receding shank should be 90 to 95 mm long and for the left adrenal gland the shank should be 115 to 140 mm long Scale in millimetres each step indicating 10 mm

aldosterone and cortisol in the venous blood, selectively sampled from the adrenal glands Even 3 mm wide adenomas were found to produce large quantities of aldosterone The phlebographies were positive in one case only and uncertain in another The width of the tumours, undetected with phlebography varied between 3 mm and 23 mm

Many factors, however, influence the results of the biochemical analyses and it is sometimes impossible to extract enough blood from the adrenal veins, in spite of an otherwise successful catheterization

Material All the cases in which epinephro phlebography was attempted (55 cases) are included in this series Angiography was performed in all of them and retroperitoneal pneumography in 17 cases The indications for epinephro phlebography were given by the preliminary diagnoses as follows primary aldosteronism 34, phaeochromocytoma 9, feminizing syndrome 4, virilizing syndrome 2, mb Cushing 1, malignant tumour 1, metastasis 2, and adrenal insufficiency in 2 cases Phlebography performed in nine healthy subjects have not been included in the series Most of the positive tumour cases were referred from the Department of Endocrinology, Karolinska sjukhuset, Stockholm

Techniques

Epinephro phlebography The catheters, the end of which forms a large loop, are differently shaped for the right and left adrenal veins They are now made solely of P E No 240 polythene tubing The shapes are shown in Fig 1

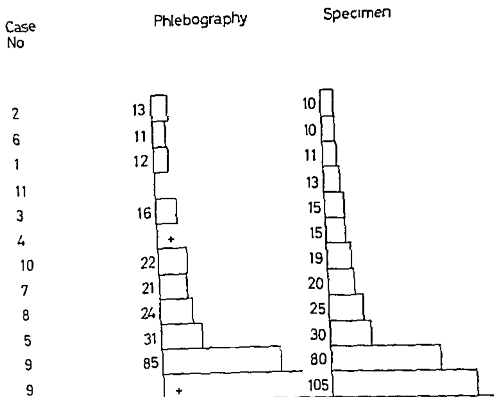


Fig 2 Width of tumours assessed at epinephro-phlebography and correlated to specimens The measures are stated with numerals and graphically in millimetres but in five of the largest specimens no closer than in half centimetres Case numbers are from Table 2 Symbol + refers to positive findings but tumour width impossible to assess

The straightened catheter is percutaneously introduced with the aid of a Seldinger No 205 guide via the right femoral vein into the inferior vena cava, the loop of the catheter being reformed during the procedure the tip spontaneously enters a renal vein but when the stem of the catheter is pushed further up the vena cava the preformed vertex of the loop of the catheter will move past the renal vein and the shape of the loop will be restored The catheter is now in correct position for examination of the adrenal veins The receding shank of the catheter for the left side is pulled into the left renal vein the tip being directed cranially against the left adrenal vein which opens into the renal vein at a distance of 2 to 4 cm from vena cava The right adrenal vein often runs upwards and usually enters the vena cava directly between the renal and hepatic veins It is sometimes possible to reach the right adrenal vein with the catheter for the left side but

Table 1

Comparison of epinephro phlebographies

Technical measure	Number of adrenal glands		
	Left side		Right side
	Original method	Modified method	
Attempted phlebographies	30	23	51
Successful phlebographies	23 (77 %)	23	36 (70 %)
Blood sampling for cortisol 3 ml	*18 (60 %)*	*23*	*25 (49 %)*
Blood sampling for aldosterone 30 ml	9 (30 %)	23	21 (41 %)

if this fails the catheter should be replaced by the one preformed for the right side The technique has been more fully described in a preliminary report (MIKAELSSON 1967)

The amount and rate of injection of the contrast medium (we use between 1 5 ml to 10 ml Urografin 76 %) are controlled with the aid of the TV monitor Roentgenograms are obtained at intervals of 0 67 seconds during 5 seconds. When the examination is completed, the catheter is straightened with a metal guide and withdrawn

Comments When the tip of the catheter for the left side is about to be turned, the receding shank is sometimes found to be a little longer than the renal vein it entered, and the stem of the catheter may then be too weak to overcome the resulting slight resistance This may be helped if the stem is temporarily straightened with a guide, which might cause slight pain to the patient, this will disappear, however, as soon as this brief manipulation is over

It is advisable, in view of the individual variations in the venous anatomy, to have a few catheters of various shapes available for use The shorter the receding shank is, the more curved should it be, particularly near the tip The angles between the big veins change somewhat with different phases of respiration, and by controlling the movements of the diaphgram it may be possible to adapt the anatomy of the veins to a catheter which otherwise appears unsuitable

An inferior phrenic vein which almost constantly joins the left adrenal vein close to the gland must be avoided The vein lies near the medial part of the gland and is about the same size as the adrenal vein

The blood pressure, which usually changes, should be checked repeatedly

Table 2

Results of epinephro-phlebography correlated to operative findings of adrenal tumours

Case	Age	Sex	Preliminary diagnosis	Findings				Definite diagnosis
				Right glands		Left glands		
				Epinephro-phlebography	Operation	Epinephro-phlebography	Operation	
1	45	♀	Primary aldosteronism (Publ. by MIKAELSSON 1968)	0	0	+	+	Aldosteronoma sin
2	49	♀	Malignant tumour	0		+	+	Indifferent adenoma pancreatitis
3	36	♀	Primary aldosteronism	0		+	+	Aldosteronoma sin
4	46	♀	Primary aldosteronism	0		+	+	Aldosteronoma sin
5	33	♀	Primary aldosteronism (Publ. by BUCHT et coll. 1964)		0	+	+	Aldosteronoma sin
6	69	♀	Primary aldosteronism (Publ. by MIKAELSSON 1968)			+	–	Aldosteronoma sin
7	43	♀	Primary aldosteronism (Publ. by MIKAELSSON 1967)			+	–	Aldosteronoma sin
8	31	♀	Virilizing syndrome (Publ. by MIKAELSSON 1967)			+	+	Androsteroma sin
9	37	♂	Phaeochromocytoma	+	+	+	+	Phaeochromocytoma bilat
10	67	o	Feminizing syndrome	+	+			Oestrogenoma dx
11	26	o	*Primary aldosteronism*		+		0	Aldosteronoma dx

Adrenal tumour present (+), no tumour found (0)

Table 3

Correlation of findings at phlebography and operation in 23 cases

Phlebography	Number of cases verified				Total number of glands verified
	Right side alone	Left side alone	Both sides		
			Right	Left	
Confirmed (positive)	1	6	1	3	11
Confirmed (negative)	2	1	6	6	15
Not confirmed	0	0	0	0	0
Catheterization impossible	1	0	5	3	9
Total	4	7	12		35

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if this fails the catheter should be replaced by the one preformed for the right side. The technique has been more fully described in a preliminary report (MIKAELSSON 1967).

The amount and rate of injection of the contrast medium (we use between 1.5 ml to 10 ml Urografin 76 %) are controlled with the aid of the TV monitor. Roentgenograms are obtained at intervals of 0.67 seconds during 5 seconds. When the examination is completed, the catheter is straightened with a metal guide and withdrawn.

Comments. When the tip of the catheter for the left side is about to be turned, the receding shank is sometimes found to be a little longer than the renal vein it entered, and the stem of the catheter may then be too weak to overcome the resulting slight resistance. This may be helped if the stem is temporarily straightened with a guide, which might cause slight pain to the patient; this will disappear, however, as soon as this brief manipulation is over.

It is advisable, in view of the individual variations in the venous anatomy, to have a few catheters of various shapes available for use. The shorter the receding shank is, the more curved should it be, particularly near the tip. The angles between the big veins change somewhat with different phases of respiration, and by controlling the movements of the diaphragm it may be possible to adapt the anatomy of the veins to a catheter which otherwise appears unsuitable.

An inferior phrenic vein which almost constantly joins the left adrenal vein close to the gland must be avoided. The vein lies near the medial part of the gland and is about the same size as the adrenal vein.

The blood pressure, which usually changes, should be checked repeatedly

Table 2

Results of epinephro-phlebography correlated to operative findings of adrenal tumours

Case	Age	Sex	Preliminary diagnosis	Findings				Definite diagnosis
				Right glands		Left glands		
				Epinephro-phlebography	Operation	Epinephro-phlebography	Operation	
1	45	♀	Primary aldosteronism (Publ by MIKAELSSON 1968)	0	0	+	–	Aldosteronoma sin
2	49	+	Malignant tumour	0		+	+	Indifferent adenoma pancreatitis
3	36	♀	Primary aldosteronism	0		+	+	Aldosteronoma sin
4	46	♀	Primary aldosteronism	0		+	–	Aldosteronoma sin
5	33	♀	Primary aldosteronism (Publ by BUCHT et coll 1964)		0	+	+	Aldosteronoma sin
6	62	+	Primary aldosteronism Publ by MIKAELSSON 1968)			+	+	Aldosteronoma sin
7	43	♀	Primary aldosteronism (Publ by MIKAELSSON 1967)			+	+	Aldosteronoma sin
8	31	¥	Virilizing syndrome (Publ by MIKAELSSON 1967)			+	+	Androsteronoma sin
9	37	♂	Phaeochromocytoma	+	+	+	+	Phaeochromocytoma bilat
10	62	♂	Feminizing syndrome	+	+			Oestrogenoma dx
11	6	o	Primary aldosteronism		+		0	Aldosteronoma dx

Adrenal tumour present (+) no tumour found (0)

Table 3

Correlation of findings at phlebography and operation in ?3 cases

Phlebography	Number of cases verified				Total number of glands verified
	Right side alone	Left side alone	Both sides		
			Right	Left	
Confirmed (positive)	1	(	1	3	11
Confirmed (negative)	2	1	6	6	15
Not confirmed	0	0	0	0	0
Catheterization impossible	1	0	5	3	9
Total	4	7	1?		35



Fig 3 Normal epinephro phlebography of the right (a) and left (b) adrenal glands

when the catheter is being introduced into one of the adrenal veins It may sometimes decrease somewhat but it may also rise, and once in this series it increased from 230 to 300 mg Hg (systolic) The blood pressure always returned to its former level however, as soon as the catheter was withdrawn from the adrenal vein The sampling of blood was carried out with a spontaneous drip in order to avoid admixture with atypical blood, 1 or 2 ml heparin are injected through the catheter to prevent coagulation and thrombosis

Angiography This examination is usually carried out with injection of the contrast medium into the aorta, and roentgenograms in different projections are obtained Selective examinations of suitable branches of the aorta, sometimes after injection of epinephrine have been performed in six cases

Retroperitoneal pneumography In these examinations, 800 to 1 200 ml oxygen have been insufflated between rectum and coccyx Tomography has been performed and films in a p , oblique and lateral projections were obtained

Results

All attempts at epinephro-phlebography are recorded in Table 1 Catheterization of the right side was attempted in 51 cases and of the left side in 53 In one case the gland on the left side could not be catheterized because the left renal vein was obliterated close to its opening into the inferior vena cava. The short remnant was examined but catheterization of the adrenal vein was impossible and the examination of this side has therefore not been included in the present series

Phlebographies with definite filling of the intraglandular veins were performed in 70 % of the right glands. On the left side, the rate of success in this respect with the original technique was 77 % in 30 cases but the sampling of blood was less successful After modification of the method for the left side 23 examinations proved successful and a sufficient amount of blood could be extracted from the glands

The findings were confirmed in 22 cases in ten of which 11 tumours were removed (Table 2) One further case could not be catheterized, probably because of a previous bilateral operative exploration with negative result, an adenoma on the right side was later removed All the other eleven tumours were clearly visible at phlebography Their size varied between 10 and 105 mm in five of the tumours between 10 and 15 mm Their actual location within the glands as well as width and shape corresponded in 9 cases to the findings at operation (Figs 2 to 8) while two tumours were only partly outlined

There were seven aldosteronomas and two phaeochromocytomas in a single case and further one feminizing one virilizing and one adenoma without hormonal activity in this group Special reports on five of these cases (1 5 6 7 and 8 in Table 2) have previously been published (BUCHT et coll 1964 MIKAELSSON 1967 1968)

The group of verified phlebographies without tumour includes ten operated cases two post mortem cases and one case of contralateral gland from the group with adrenal tumours Fifteen glands were verified seven by careful histologic examination and eight by inspection and palpation in situ No adrenal tumour was detected Seven of these cases were operated upon for clinical and biochemical reasons while three others were submitted to nephrectomy

In the whole control material of 23 cases phlebography of 26 glands was performed The phlebographic information was correctly positive for 11 glands, correctly negative for 15 glands (seven of which were histologically verified) No false information was obtained (Table 3)

Typical phlebographic appearance in adenoma Two normal phlebographies are presented in Fig 3 The adenomas are well defined and usually spherical



a



b



c

Fig 4 Case 2 Phlebography of adenoma of left adrenal gland without hormonal activity Displaced flattened veins around the adenoma (a) and veins that look narrow and compact in another projection (b) Specimen in (c)



a b



c

Fig 5 Case 10 Phlebography of feminizing adenoma at upper aspect of the right adrenal gland Somewhat incomplete contrast filling of the veins around the tumour in (a) and more complete filling in (b) Specimen cut open in (c) The upper border of the gland is seen to the right

or oval in shape Their minimum diameter has in this paper been used as a measure of their size No veins could be detected within the tumours themselves but vessels surrounding them in the adrenal parenchyma were displaced and somewhat compressed in a radial direction Thus the veins appeared either wide and compressed or narrow and compact depending on the projection (Fig 4) As there is a profuse network of veins within the parenchyma, these appearances are striking Small veins directed towards the adenoma broke off abruptly at the



Fig 6 Case 5 Aldosteronoma of the left adrenal gland a) Angiography venous phase (arrows) b) Phlebography (Case publ by Bucht) Large venous sinuses around the tumour the adrenal gland is like a small shell (arrows)

surface of the lesion and continued as compressed veins running alongside the tumour (Figs 4, 5 and 6)

The cortical adenomas are often situated close to the surface of the glands In six specimens, one part of the tumour was free from the adrenal tissue, and four adenomas lay like eggs in their cups (Cases 1, 2, 6, 10) They were clearly seen on phlebography, however, in spite of the location (Fig 4)

The adrenal gland in Case 5 (Table 2) lay like a small shell at the side of the large adenoma which, because of surrounding wide veins, appeared bluish at operation The veins around the tumour and in the adrenal gland were filled at phlebography and had of course similar appearance and distribution (Fig 6)

Two further aldosteronomas are presented in Figs 7 and 8

Discussion

The study of many cases was often greatly helped by examinations in different projections The equipment hitherto available has permitted only one



Fig 7 Case 3 Phlebography of aldosteronoma of the l ft adrenal gl nd (arrows)



a



b

F g 8 Cas 4 Phlebogr phy (a) of aldosteronoma of th left adrenal gland (arrow) and specimen (b)

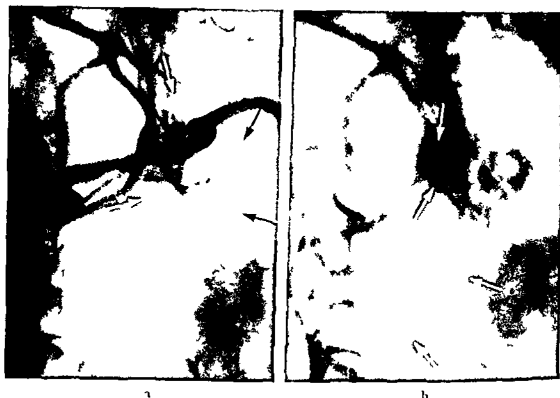


Fig 9 Case 2 Angiography of adenoma without hormonal activity in the left adrenal gland (pancreatitis present) a) Arterial phase hypervascular spot at left adrenal gland (arrows) b) Venous phase profuse venous network veins around the adenoma and filling of the main adrenal vein (arrows) (Phlebography of the same case is shown in fig 4)

projection per injection which constitutes a considerable disadvantage A modern unit is now being procured, which will permit examinations in several planes by turning the patient in a cradle between the exposures (Different projections are important also in the angiographic examination of the adrenal glands as stressed by AHLBACK in 1958) Recording of the information on the TV monitor will be possible and should be of particular value when the test injection alone has been successful, as occasionally happens because of extravasation of the contrast medium

Small discrepancies between the width of the adenoma at phlebography and at operation, respectively, may be explained by the occurrence of geometrical enlargement, by variations in projection and by the possible presence of a compressed vein in the neighbourhood of the tumour

The smallest adenomas in this series were detected with the same accuracy as the larger growths, and even smaller tumours may be discovered Since the lesions lie at the surface of the glands it is important to demonstrate the cortical

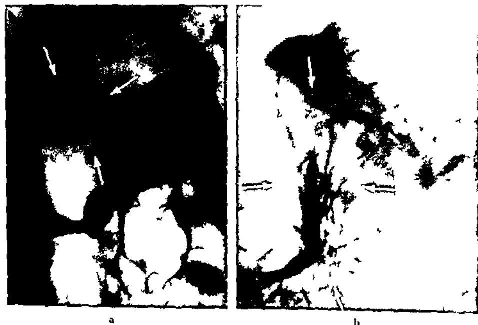


Fig 10 Hypernephroma of upper pole of left kidney a) Angiography Mass at the medial part of the upper renal pole b) Phlebography Normal adrenal gland

part of the venous system as well This implies an increased intravasal pressure during the injection as the contrast medium will have to be directed against the blood stream The amount of medium and rate of injection necessary to achieve this pressure depend upon the capacity of the venous system and on possible reflux of medium along the catheter into the large veins The increased pressure during the injection causes pain of a typical nature which may require general anaesthesia this will however also affect the hormones in the blood samples As the pain is of short duration and in a mild form is often helpful during the catheterization of the right side the patients should not be anaesthetized if it can be avoided

Thirty per cent of the right side phlebographies were unsuccessful This rate was constant throughout the series and can probably at least in part be explained by variations in the anatomy It is known that the right adrenal gland may be drained by two or three veins and the width of anyone of these may not permit the introduction of a catheter The adrenal vein sometimes opens either into a vein from the liver or the kidney or occasionally into an accessory caval



Fig 11 a) to c) Examinations of a case of an enlarged right gland and respectively an adrenal tumour a) Retroperitoneal pneumography b) Phlebography of the same gland as in (a) no tumour c) Retroperitoneal pneumography of Case 10 The tumour seen in fig c cannot be distinguished from the general enlargement of the gland d) Phlebography of another case Small extravasal deposit of contrast medium at the periphery of the left adrenal gland

vein (ANSON, and JOHNSTONE) The frequency of these variations has not been reported however

Apart from the two large phaeochromocytomas five adrenal tumours out of ten were revealed at angiography one in the arterial phase two in the capillary, and four in the venous phase as well In four adenomas, the width of which was below 19 mm selective angiography was negative A 10 mm adenoma (Case 2 Table 2) became visible due to special circumstances Pancreatitis caused wide venous communications to the left adrenal gland The adenoma appeared in the venous phase at angiography (Fig 9) but was more clearly outlined at phlebography which also revealed its situation within the gland (Fig 4) Communicating veins between the left adrenal gland and the pancreas (as well as between the right adrenal gland and the capsule of the liver) have been described by many authors They were in this particular case probably enlarged due to the presence of pancreatitis

In two cases, the left adrenal gland was stated to be normal at phlebography while other examinations had suggested an expanding lesion in the region The lesions were subsequently proven to be associated with the kidney (Fig 10)

Retroperitoneal pneumography was carried out in 17 cases Five patients were operated upon one of them without radiologic indications An adenoma and two large glands were present on the right side and two large glands on the left side All the glands had appeared pathologically enlarged at pneumography excepting one on the left side The left adrenal gland because it lies in front of the kidney is more difficult to detect by angiography and pneumography than the right gland The smallest gland detected measured 25 mm × 35 mm in the films The tumour (Case 10 Table 2) and the generally enlarged glands bore the same appearances (Fig 11)

Complications One thrombosis of the right iliac vein was mentioned in the preliminary report One further thrombosis of the great saphenous vein occurred the day after phlebography The clinical signs disappeared after a few days. Extravasal deposits of medium in the adrenal glands usually emanating from the peripheral vessels (Fig 11d) were observed in six cases Apart from pain in the back for some hours after the examination no clinically untoward disturbances have developed

Conclusions

1 Seventy per cent of 55 cases were successfully examined by right side epinephro-phlebography Seventy seven per cent of the cases were initially successfully examined on the left side After modification of the technique however

all the glands (23) could be examined without difficulty, and the sampling of adrenal venous blood was facilitated

2 The tumours displace the surrounding veins, which are compressed in a radial direction and widened tangentially The course of contiguous veins in the adrenal parenchyma is abruptly broken by the neoplasm

3 Tumours with a minimum width of 10 mm were ordinarily visible in this series, the small growths being as clearly seen as the larger ones Phlebography has proved superior to angiography, with which small neoplasms could usually not be detected

No distinction could be made by means of retroperitoneal pneumography between small tumours and hyperplasia

SUMMARY

A new technique for epinephro phlebography has been developed and was employed in a material of 55 cases Seventy per cent of the right and all the left adrenal gland could be examined with this technique Operation or autopsy were performed in 23 cases The phlebographies of 26 glands were checked and the diagnoses of eleven adrenal tumours were confirmed

ZUSAMMENFASSUNG

Eine neue Technik fur Epinephro Phlebographie wurde entwickelt und bei Untersuchung von 55 Patienten angewendet Mit dieser Technik konnten 70 % der rechten und alle linken Nebennieren dargestellt werden In 23 Fallen lag ein Operations oder Sektions Befund vor Insgesamt wurden 26 phlebographische Untersuchungen kontrolliert und die Information beweis sich in jedem Falle korrekt Die Diagnose von elf adrenalen Tumoren wurde bestatigt

RÉSUMÉ

L auteur a utilisé dans une série de 55 cas une nouvelle technique pour la phlebographie des surrénales Il a examiné 70 % des surrénales droites et toutes les surrenales gauches Une verification chirurgicale ou necropsique a été faite dans ces 23 cas Les phlébographies de 26 surrénales ont ete controlees et verifiées et 11 tumeurs surrenales ont ete correctement diagnostiquees

REFERENCES

AHLBACK S The suprarenal glands in aortography Acta radiol 50 (1958) 341

ANSON B J CAULDWELL E W PICK J W and BEATON L E The blood supply of the kidney, suprarenal gland and associated structures Surg Gynec Obstet 84 (1947) 313

Bucht H Percutaneous catheterization of the left adrenal vein in man Scand J clin Lab Invest 14 (1962) Suppl No 64 p 27
— Bergstrom J Lindholmer B et coll Catheterization of the left adrenal vein for contrast injection and steroid analysis in a case of Conn s syndrome Acta med scand 176 (1964) 233
Busch W Die arterielle Gefässversorgung der Nebennieren Z mikr anat. Forsch 61 (1954/55) 159
Johnstone F R C The suprarenal veins Amer J Surg 94 (1957) 615
Kahn P C Selective angiography of adrenal glands. Amer J Roentgenol 101 (1967) 739
Kliman B and Peterson R E Double isotope derivative assay of aldosterone in biological extracts J biol Chem 235 (1960) 1639
Kutschera Aichbergen H Nebennierenstudien Frankfurt. Z Path 28 (192?) 262
Lagergren C Angiographic changes in the adrenal glands Amer J Roentgenol. 3 (1967) 732
Lang E K Nourse M Mc Callum D et coll Diagnosis of suprarenal masses by retroperitoneal air studies and arteriography J Urol 94 (1965) 220
Lindvall N Pharmakoangiographie bei Nierenkarzinom und Nierenbeckentumoren Urologe 6 (1967) 126
Maresch W Die Venenmuskulatur der menschlichen Nebennieren und ihre funktionelle Bedeutung Wien klin Wschr 34 (1921) 44
Melby J C Spark R F and Dale S L Diagnosis and localization of aldosterone producing adenomas by adrenal vein catheterization New Engl J Med 277 (1967) 1050
Mikaelsson C G Retrograde phlebography of both adrenal veins a preliminary report Acta radiol Diagnosis 6 (1967) 348
— Epinephro-phlebography in two cases of Conn s syndrome Acta radiol Diagnosis 7 (1968) 410
Reuter S R Blair A J Schteingart D E and Bookstein J J Adrenal venography Radiology 89 (1967) 805
Sutton D Diagnosis of Conn s and other adrenal tumours by left adrenal phlebography Lancet 7540 (1968) 453
Winkler S S and Kahn P C Pharmacologic aids in adrenal angiography Invest Radiol 2 (1967) 48

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NORMAL TOPOGRAPHY OF THE CEREBRAL VESSELS IN CHILDHOOD

by

K BERGSTROM, H LODIN and H G OTTANDER

The roentgenologic anatomy of the cerebral vessels has been treated in detail by only a few authors e g SCHIEFER & VETTER (1957), TAVERAS & POSER (1959) and TAVERAS & WOOD (1964) The first two authors analysed a material of 265 normal subjects from the age aspect The material was divided into 15 age groups, each comprising a 5 year age period, and included 52 children aged 1 to 15 years, with a distribution of 9, 17 and 26 cases in, respectively, the first, second and third 5 year periods The material also included 64 subjects of ages between 16 and 30 years The appearances and position of the carotid siphon, as well as the anterior and middle cerebral arteries, were investigated Since the material comprised only carotid angiographies, no adequate evaluation of the vessels in the posterior cranial cavity could be made TAVERAS & POSER and TAVERAS & WOOD studied mainly the position of the middle cerebral arteries, and an analysis was made among about 80 subjects aged 0 to 12 years in year group by year group, of 1 child<1 year, 8 children<3 years and 16 children<5 years

The present investigation was aimed at investigating changes in position of

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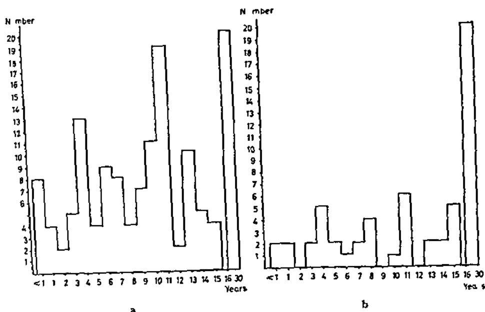


Fig 1 Age distribution carotid angiographies (a) and vertebral angiographies (b)

the larger cerebral vessels (arteries and deep veins) in relation to certain fixed points in the vault and base of the skull during the period of growth

Material The investigation was based on a material of 115 carotid and 36 vertebral angiographies of normal children of up to 15 years of age Encephalography had been performed in all cases with negative results The age distribution is given in Fig 1 With a few exceptions the same technique (rapid serial angiography) and the same film focus-distance were used for all the angiographies so that the magnification factors varied only with the breadth and length of the individual head No correction for magnification was made

A group of 20 subjects aged 16 to 30 years with normal carotid angiographies and encephalographies was used as control material for certain determination together with a group of the same number with normal vertebral angiographies and encephalographies

Measurement technique Different parts of the intracranial vascular system were studied with the aid of reference points and lines that are described in detail in the reports of the respective measurements (LODIN 1968 CARLSSON & LODIN 1969) The method included both direct measurements of distances be

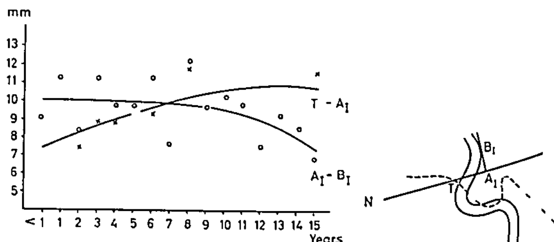


Fig 2 Relationships of the carotid siphon mean values N—T = nasion tuberculum sellae line A_I = the point where the normal from the posterior contour of the upper shank (B_I) meets the N—T line

tween different points, and calculations of ratios of various distances The mean values for the respective distances and ratios were calculated for each year group, these are presented as coordinate systems, and curves have been interpolated between the values obtained

Results

I Arteries

Carotid siphon The relative position of the upper shank of the carotid siphon was analysed (Fig 2) The reference line between the nasion and tuberculum sellae (N—T) was projected, and the normal from this line up towards the posterior contour of the upper shank of the carotid siphon was drawn (A_I—B_I) The distances T to A_I and A_I to B_I were measured, by means of which the position of the upper shank in relation to the tuberculum sellae, as well as its height above the N—T line, could be determined As may be seen from Fig 2, distance T to A_I increases continuously up to the age of 9 to 10 years, the distance A_I to B_I remaining relatively constant, but then decreasing Thus, with increasing age the upper carotid shank becomes less vertical and is displaced in an occipital direction to come closer to the base of the skull

Carotid bifurcation The positions of the first parts of the anterior and middle cerebral arteries were studied The frontal angiogram was obtained with the central ray parallel to the bottom of the anterior cranial cavity, and a reference line perpendicular to the midline was drawn through the most superior part of

Table

Positions of the proximal parts of the anterior and middle cerebral arteries — Compare with Fig 3

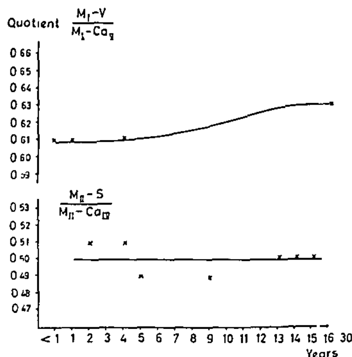
	Anterior and middle cerebral arteries		Anterior cerebral artery		Middle cerebral artery	
Age in years	0—7	8—15	0—7	8—15	0—7	8—15
N	25	33	41	53	41	53
Above (+)	56	10	41	21	49	15
Horizontal	*20*	*57*	*27*	*43*	*29*	*43*
Below (—)	24	33	32	36	22	42

the internal carotid artery, immediately adjacent to the point of bifurcation The positions of the proximal parts of the anterior and middle cerebral arteries were then determined in relation to this line (Fig 3) The plus sign indicates that the respective arterial parts were situated above the reference line the minus sign that they were below the line and horizontal means that they lay level with this line The proximal parts of the anterior and middle cerebral arteries were symmetrically situated in relation to the reference line in 58 out of 94 cases that could be evaluated while asymmetry was apparent in the remaining 36 cases

The material was divided into two groups a young group aged 7 years and under and an older group of 8 to 15 years It was found that in 56 % of the younger group the proximal parts of both the anterior and middle cerebral arteries lay above the reference line while this held for only 10 % of the older group (see Table) On studying each vessel separately, in the whole material of 94 cases the following observations were made The same differences between the two groups were apparent even when the asymmetric conditions of the carotid bifurcation were taken into consideration The first part of the middle cerebral artery lay above the given reference line in half of the younger group,



Fig 3 Anterior and middle cerebral arteries in relation to a reference line through the most superior part of the internal carotid artery (cf Table)



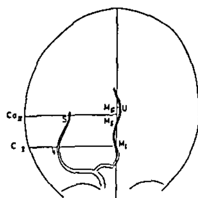
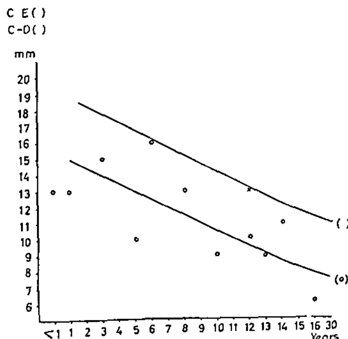


Fig 4 Relationships of the middle cerebral artery in the frontal projection mean values M_I and M_{II} = points on the midline Ca_{IV} and Ca_V = points at the cranial vault V = medial part of the Sylvian group at level of insula S = behind the insula



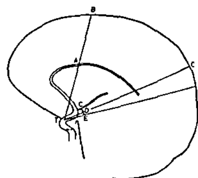


Fig 5 Relationships of the middle cerebral artery in lateral projection mean values T—L = tuberculum sellae—lambda line T—Ca_I = clinoparietal line (line of Taveras) C—D and C—E = the distances from the lower Sylvian branch to the T—Ca_I and T—L lines at distances of 2 cm from tuberculum sellae

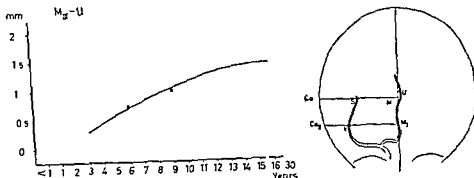
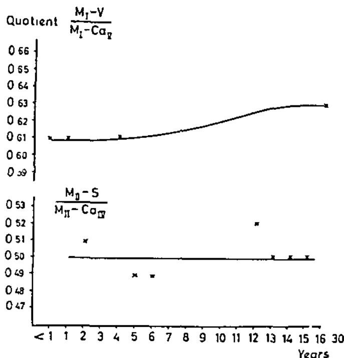


Fig 6 The maximal distance of the pericallosal artery from the midline mean values.

while the corresponding part of the anterior cerebral artery lay above the line in about two-fifths The results illustrate the relatively high frequency of the infantile type of branching even up to the age of 7 years (cf Table)

Middle cerebral artery The relationship between the distal part of the middle cerebral artery and the skull was studied in the frontal projection (Fig 4) The relative position of the vessel was determined by calculating the ratios between the maximal distance from the midline to the medial part of the Sylvian group at the level of the insula (M_I to V) as well as between the minimal distance behind the insula (M_{II} to S) and half the inner cranial diameter or M_I to Ca_I and M_{II} to Ca_{II} respectively As may be seen from Fig 4 the ratio for the larger distance i e at the level of the insula region showed a tendency to increase with age On the other hand no definite change was observed in the ratio for the posterior measuring point behind the insula region

The topographic relationships of the middle cerebral artery and the Sylvian group were studied in the lateral projection with the aid of the following reference points and lines (see Fig 5) As reference lines to the cranial bones both the so-called clino-parietal line described by TAVERAS i e a line from the tuberculum sellae to a point 2 cm frontal to the lambda (T—Ca_I) and the line between the tuberculum sellae and the lambda (T—L) were used Normals were drawn to the lowest main branch of the Sylvian group at distances of 2 cm along these lines measured from the tuberculum sellae The distances C—D and C—E i e the distances from the lower Sylvian branch to the clino-parietal line and the tuberculum lambda line respectively were measured It is evident from Fig 5 that the Sylvian group as represented by this most basally situated large



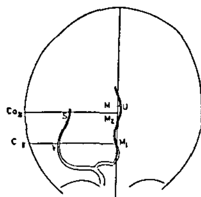
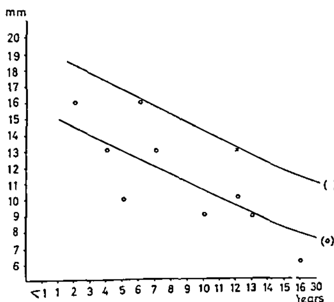


Fig 4 *Relationships of the middle cerebral artery in the frontal projection mean values* M_I and M_{II} =points on the midline Ca_{IV} and Ca_V =points at the cranial vault V=medial part of the Sylvian group at level of insula S=behind *the insula*



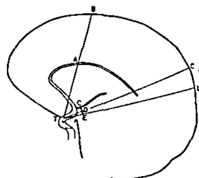
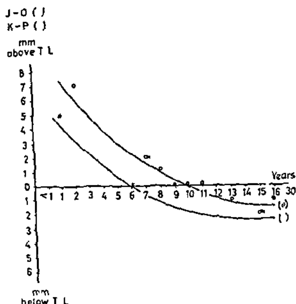


Fig 5 Relationships of the middle cerebral artery in lateral projection mean values T—L=tuberculum sellae—lambda line T—Ca_I=clinoparietal line (line of Taveras) C—D and C—E=the distances from the lower Sylvian branch to the T—Ca_I and T—L lines at distances of 2 cm from tuberculum sellae



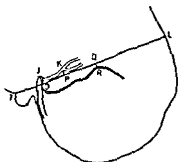


Fig 8 The positions of the basilar artery and the posterior cerebral artery in relation to the tuberculum—lambda line (T—L) mean values J—O = the distance from the top of the basilar artery to the T—L line K—P = the distance from the ramification point of the posterior cerebral artery to the T—L line

Posterior cerebral artery The study of the anatomical relationships of the posterior cerebral artery was based on angiographies from 65 cases including 36 vertebral angiographies

For the lateral projection (see Fig 8) the line T—L was used as reference line The distance between the point of ramification of the posterior cerebral artery as it divides into the posterior temporal and internal occipital branches and this line was measured (K to P) Up to the age of about 6 years this ramification point is situated above the line T—L and after the age of 7 years below the line The conditions are thus the same as for the upper part of the basilar artery

For the frontal projection (Fig 9) the ratio between the greatest distance from the posterior cerebral artery to the midline (M_{IX} to X) as well as between the smallest distance (M_Y to Y) and half the inner cranial diameter were determined (M_{IX} to Ca_{VII} and M_Y to Ca_{VI} respectively) Both these ratios increase in a moderate degree up to the age of 10 years

Superior cerebellar artery The relationship of the superior cerebellar artery to the tuberculum lambda line (T—L) was determined by measuring the smallest distance between them (R to Q) only in those angiograms where R could be identified with certainty was this evaluation made (12 cases) The individual

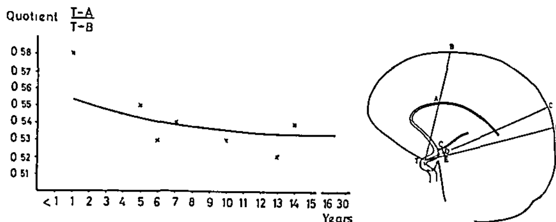


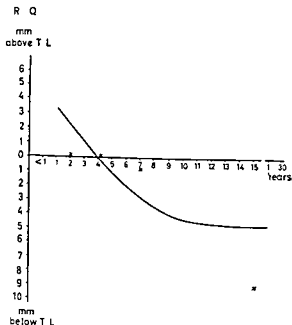
Fig 7 The position of the pericallosal artery in relation to the cranial cavity mean values A=point where the tuberculum—bregma line (T—B) intersects the pericallosal artery

branch, is displaced continuously with increasing age downwards towards both the clino-parietal line (T—Ca_I) and the tuberculum lambda line (T—L)

Pericallosal artery The pericallosal artery was studied from two aspects, first with regard to its general tortuosity around the midline (Fig 6), and secondly with regard to its position in relation to the cranial vault (Fig 7) Its tortuosity around the midline in the frontal projection was determined by measuring the maximal distance from the pericallosal artery to the midline (M_{III} to U) The tortuosity, as revealed in the frontal projection (Fig 6), increases with increasing age

The relationship between the pericallosal artery and the cranial vault in the lateral projection was determined by means of a reference line drawn between the tuberculum sellae and the bregma (T—B) The position of the pericallosal artery at the point of intersection with this line (A) was determined by calculating the ratio between distances T—A and T—B as demonstrated in Fig 7 A slight tendency to a reduction of this ratio during early childhood is apparent, this is probably an expression of the relatively larger growth of the frontal lobe in comparison with the more basally localized structures near the midline

Basilar artery In studying its relative position, only the upper part of the artery was considered (Fig 8) The height of this upper part (J—O) was determined in relation to the tuberculum sellae lambda line (T—L) It is apparent from Fig 8 that the position of the upper part of the basilar artery is displaced in a caudal direction, so that at the age of 10 years it lies above the line T—L but after this time below it



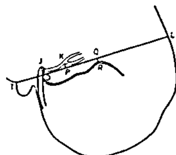
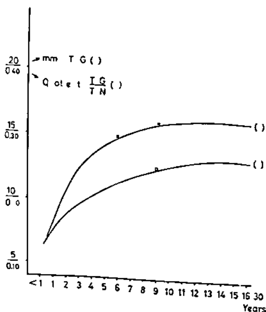


Fig 10 The position of the superior cerebellar artery in relation to the tuberculum—lambda line Q—R = the smallest distance between this artery and the T—L line O = mean value for the 16—30 year group



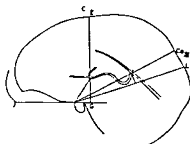
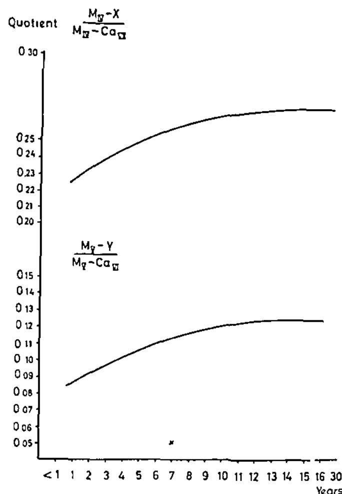


Fig 11 The position of the venous angle (F) in relation to the extended nasion—tuberculum line (N—T) mean values G = the point where the normal from F meets the N—T line



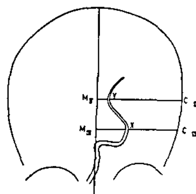


Fig 9 Relationships of the posterior cerebral artery in frontal projection mean values M_{IV} and M_V = points on the midline Ca_{VI} and Ca_{VII} = points at the vault X = the most lateral and Y = the most medial position of the posterior cerebral artery

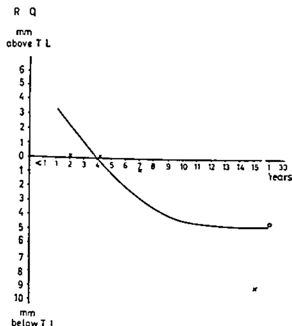
values are plotted for the age group 0 to 15 years but the mean value for the control group 16 to 30 years (Fig 10) A distinct tendency is evident in the diagram as in the case of the posterior cerebral artery and the upper part of the basilar artery, the superior cerebellar artery becomes displaced in a caudal direction in relation to line T—L

No further analyses of arteries within the posterior cranial cavity were possible owing to the limited number of vertebral angiographies

II Deep venous system

The relationships of the deep venous system in the lateral projection were studied from 50 carotid angiographies

Venous angle (foramen of Monro) The confluence (F) of the septi pel lucidi vein and the thalamostriate vein (venous angle), which also corresponds



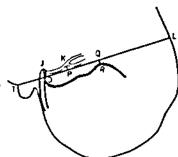
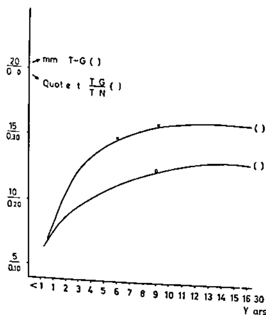


Fig 10 The position of the superior cerebellar artery in relation to the tuberculum—lambda line Q—R = the smallest distance between this artery and the T—L line O = mean value for the 16—30 year group



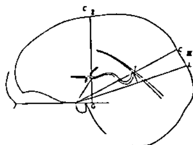
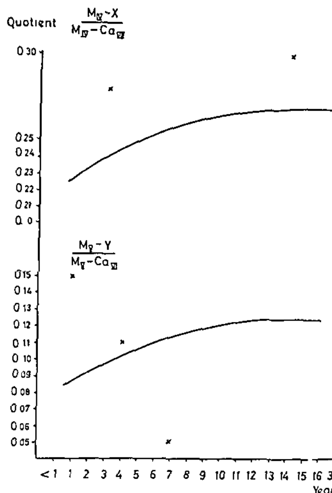


Fig 11 The position of the venous angle (F) in relation to the extended nasion—tuberculum line (N—T) mean values G = the point where the normal from F meets the N—T line



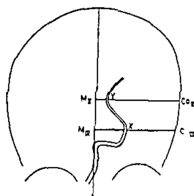


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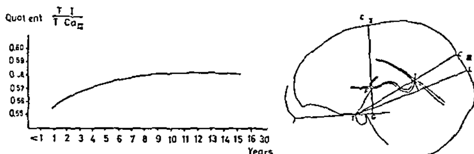


Fig 13 The position of the confluence of the great cerebral vein and inferior sagittal sinus (I) in relation to the vault (Ca_{III}) mean values

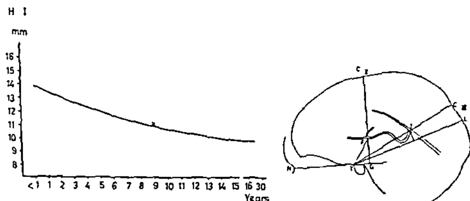


Fig 14 The position of the confluence (I) in relation to the tuberculum—lambda line (T—L) mean values H = the point where the normal from I meets the T—L line

Discussion

The diagrams afford only a schematic representation of the changes in position of the larger arteries and the deep venous system during the period of growth The mean values throughout vary more than in the analysis of the normal displacement of the ventricular system This may be because the ventricular system is more easily analysed and because of the greater variations in arrangement of the arterial vascular system

The changes in position of the middle cerebral artery and the Sylvian group are explained by the growth of the frontal components of the cerebrum and the insula region this causes displacement of these vessels both in a basal direction

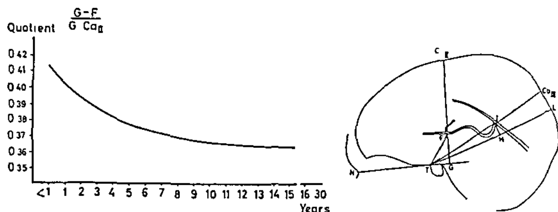


Fig 12 The position of the venous angle (F) in relation to the vault (Ca_{II}) mean values

to the position of the foramen of Monro, was determined in relation to the cranium (Fig 11) The line projected from the nasion to the tuberculum sellae (N—T), as well as the normal from this line through the confluence of the two veins to the cranial vault (G to Ca_{II}), were used as reference lines The distances T—G and T—N were determined and the ratio between them calculated so that the approximate ratio between the distance T to G and the length of the skull was obtained The ratio between distances G to F and G to Ca_{II} was also calculated The diagram reveals that during the first 5 to 7 years the position of the venous angle changes relatively rapidly in an occipital direction

As may be seen from the diagram in Fig 12, the venous angle also becomes displaced in a basal direction during the same period

Relative displacements of the foramen of Monro in basal and occipital directions are thus always present during the first 5 to 7 years of life

Confluence of great cerebral vein and inferior sagittal sinus The confluence (I) of the great cerebral vein and the inferior sagittal sinus and the sinus rectus, respectively, was studied (Figs 13 and 14) Both the line from the tuberculum sellae through the confluence (I) to the cranial vault (T to Ca_{III}), and the tuberculum lambda line (T to L) were used as reference lines The position of the confluence (I) was determined both by calculating the ratio between T to I and T to Ca_{III}, and by measuring the distance I to H where H was the point at which the normal from I intersected the line T—L A change in position, though relatively negligible of point I towards the cranial vault and away from the tuberculum sellae is present in Fig 13 It is also evident from Fig 14 that with increasing age the confluence (I) approaches the tuberculum lambda line, i e it is displaced in the direction of the occipital foramen, the position of the confluence changes thus both in a parieto-occipital and a caudal direction

the confluence of the great cerebral vein with the inferior sagittal sinus in an occipital direction is similarly in full agreement with the change in position of the aqueduct and the fourth ventricle Finally the displacements of the posterior cerebral artery, the peak of the basilar artery and the superior cerebellar artery agree with the change in position of the fourth ventricle towards the oc capital squama

The growth conditions are also reflected in the size changes of the basal cisterns (CARLSSON & LODIN) The depth of the suprasellar cisterns decreases and that of the interpeduncular cistern increases to the same degree as the basal and dorsal displacements of the third ventricle and the dorsal displacement of the aqueduct The depth and lateral extension of the pontocerebellar cisterns decrease at the same rate as the increase in volume of the pons region, which is also reflected in the relative lateral displacement of the posterior cerebral arteries On the other hand the absolute depth of the pontine cistern and the relative ize conditions of the cisterna magna do not change

The essential changes in position of both the ventricular system and the larger cerebral vessels in relation to the cranial vault are completed by the age of 5 to 7 years but the displacements of the ventricular system are most marked during the first two years of life All these normal changes in position are mainly due to the great increase in size of the cerebrum This causes relative displacement of supratentorial structures in a basal and occipital direction (third ventricle, upper carotid shank and the vessels of the Sylvian group) There is also a change in position of structures lying close to and below the tentorium in a parieto-occipital direction (aqueduct fourth ventricle and the confluence of the great cerebral vein and inferior sagittal sinus) as well as towards the foramen magnum (fourth ventricle upper part of basilar artery posterior cerebral artery and superior cerebellar artery)

Conclusions

The upper shank of the carotid siphon has a more frontal and vertical position in the younger age group as compared to adults

The proximal parts of the middle and anterior cerebral arteries in the frontal projection produce an ascending impression during the first 6 to 7 years of life

A relative increase occurs in the maximal distance to the midline of the branches of the middle cerebral artery at the level of the insula region while posterior to this region the distance to the midline is constant From the lateral view it may be observed that a continuous displacement of the Sylvian group in basal direction takes place throughout the years of childhood

The tortuosity of the pericallosal artery increases and the relative displace

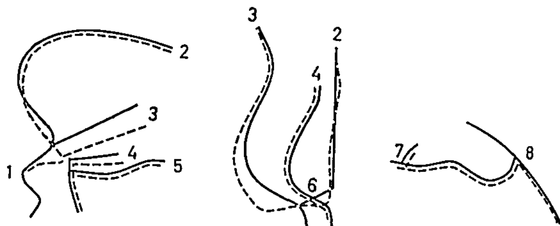


Fig. 15. Changes in positions of the main cerebral arteries and the deep venous system during the period of growth. Dotted lines indicate displacements of vessels. (1) upper shank of carotid siphon; (2) pericallosal artery; (3) middle cerebral artery; (4) posterior cerebral artery; (5) superior cerebellar artery; (6) anterior cerebral artery; (7) confluence of septal and strio-thalamic veins; (8) confluence of great cerebral vein and inferior sagittal vein.

as well as, at the level of the insula, somewhat laterally. The relative displacement of the posterior cerebral artery away from the midline during the first 5 to 7 years indicates that the growth of the brain stem components is relatively greater than that of the adjacent components of the cerebral hemisphere.

The measurements described are of only limited value in the evaluation of individual cases, but when presented collectively the results indicate the normal pattern and illustrate the developmental tendency during the growth period (Fig. 15).

Lack of knowledge of the differences in topography between the intracranial vascular systems of the child and the adult may lead to erroneous interpretation of angiographies. This applies in particular to the special topography of the carotid siphon as well as of the anterior cerebral artery and the Sylvian group: it has contributed to over-diagnosis of both suprasellar and temporal expansions and dilatation of the lateral ventricles (hydrocephalus).

The most rapid phase of development of the ventricular system is mainly completed by the age of 2 years, after which only minor changes occur in its absolute and relative size (LODIN 1968).

The analyses reported in earlier investigations (LODIN 1968 and CARLSSON & LODIN 1969) disclose complete mutual agreement morphologically. The change in position of the venous angle in a posterior and basal direction corresponds with the displacement of the optic recess of the third ventricle. The entire third ventricle is thus displaced basally and dorsally. The displacement of

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SCINTIGRAPHY AND ANGIOGRAPHY IN DEMONSTRATION OF HEPATIC TUMOURS

by

O BARTLEY C G HELANDER B ROSENGREN and S STATTIN

Clinical manifestations of expansive processes in the liver usually appear late and are often inconclusive The conventional roentgen examination even combined with pneumoperitoneum yields limited information about the size and shape of the liver Demonstration of expansive processes by these methods necessitates the changes being situated superficially and that tangential projections be used Deep lesions may be demonstrated by angiography and scintigraphy

Gamma emitting isotopes that can be concentrated in the liver are used in scintigraphy Radioactive gold ^{198}Au which is concentrated in the reticulo-endothelial system and iodine ^{131}I are examples of such isotopes The latter can be coupled to rose bengal which concentrates in the liver parenchyma or to serum albumin which is taken up by the hepatic tumour The whole hepatic region is scanned and the radiation from a small area is measured with a well collimated detector (STIRRET et coll 1954) The scintigram may be produced mechanically or photographically Precise scintigraphy of small expansive processes is still prevented by two factors unsharpness due to respiratory movements and poor resolution (at the best some 2 centimetres) Hence processes smaller

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ment of this artery towards the base of the skull is evident in the lateral projection at the level of the bregma

The upper part of the basilar artery and the posterior cerebral and superior cerebellar arteries change their positions, mainly during the first 5 to 7 years of life, in the direction of the foramen magnum It is evident from the frontal projection that a relative displacement of the posterior cerebral artery away from the midline takes place during the same period

The venous angle of the deep venous system is markedly displaced posteriorly and basally during the first 5 to 7 years of life A less obvious displacement of the confluence between the great cerebral vein and the inferior sagittal sinus, i e the highest point of the tentorium, takes place in a parietal occipital direction and towards the occipital squama

SUMMARY

The positions of the larger cerebral vessels in relation to fixed points of the skull during the different periods of growth were investigated in a material of 115 carotid and 36 vertebral angiographies of normal children of up to 15 years of age

ZUSAMMENFASSUNG

Die Lage der grossen Gehirnarterien im Verhaltnis zu festgelegten Punkten im Schadel bei verschiedenen Wachstumsperioden wurde an einem Material von 115 Karotisangiographien und 36 Vertebralis angiographien von normalen Kindern bis zum Alter von 15 Jahren studiert

RÉSUMÉ

Les auteurs ont etudie sur 115 angiographies carotidiennes et 36 angiographies vertébrales d enfants normaux jusqu a 15 ans la position des grands vaisseaux du cerveau par rapport a des points déterminés du crane au cours des differentes periodes de la croissance

REFERENCES

CARLSSON B and LODIN H Size of interpeduncular pontine pontocerebellar cisterns and cisterna magna in childhood Acta radiol Diagnosis 8 (1969) 65

LODIN H Size and development of the cerebral ventricular system in childhood Acta radiol Diagnosis 7 (1968) 385

— Normal topography of the cerebral ventricular system in childhood Acta radiol Diagnosis 7 (1968) 512

SCHIEFER W und VETTER K Das zerebrale Angiogramm in den verschiedenen Altersstufen Zbl Neurochir 17 (1957) 218

TAVERAS J M and POSER C M Roentgenologic aspects of cerebral angiography in children Amer J Roentgenol 82 (1959) 371

— and WOOD E H Diagnostic neuroradiology Williams & Wilkins Company Baltimore 1964

Table 1

Results in 11 cases without hepatic tumour

Angiography		Scintigraphy	
+	—	+	—
0	11	2	9

Table 2

Results in 19 cases with hepatic tumour

Angiography		Scintigraphy	
+	—	+	—
16	3	11	8

Most of the angiographies were of selective examinations of the celiac artery or the hepatic artery after puncture of the femoral artery and the insertion of a No 205-Ödman roentgen-opaque catheter In patients with vascular anomalies and liver supply from the superior mesenteric artery the examination was supplemented by selective *contrast injection into this artery* as well The contrast medium 30 ml Urografin 60 % was manually injected and films were obtained with an automatic film changer during about 15 seconds after start of injection Selective catheterization could not be performed in 8 cases and was replaced by aortography with 50 ml Urografin 60 % injected with a Cidlund Elema pressure *syringe*

Results

Scintigraphy as well as angiography were carried out within a few days in 30 adults 19 of whom had either primary hepatic tumours or metastases (all verified) No signs of a growth were evident in 11 cases of these autopsy in six *and laparotomy in four patients failed to disclose a hepatic neoplasm* The remaining patient is still alive about 2 years after the examination and has no clinical signs of a growth

Table 1 presents the findings in the eleven patients without a hepatic neoplasm None of these exhibited changes suggestive of a tumour at angiography but two patients *were positive at scintigraphy both had hepatic cirrhosis*

Expansive processes were demonstrated by angiography in sixteen of the 19 patients with hepatic neoplasms and in eleven by scintigraphy (Table 2)

The patients have been divided into 3 groups those with primary tumours (Table 3) those with *metastases richly vascularized (Table 4)* and those with metastases without a demonstrable blood supply (Table 5)

The lesions were correctly diagnosed by angiography in the first group comprising three cases of *hepatocellular carcinoma* and one with a cavernous haemangioma. The haemangioma, about 7 cm in diameter was not detected at *scintigraphy*

Hepatic metastases rich in vessels were present in 7 cases (Table 4) Because

than 2 cm can hardly be demonstrated by scintigraphy even if the radioactive intensity gradient is steep enough Even if a region in the liver has an intensity gradient adequate for demonstration, it may lie so deep that the superimposition of normal tissue masks the reduced uptake so that processes larger than 2 cm may remain unobserved Therefore, to improve the procedure, a scintigraphic technique with photographic recording has been elaborated Exposures are made at separate intensity steps and discrimination levels The electric signals from the scintigram are usually recorded on magnetic tape (BERNE & JONSSON 1959)

Scintigraphy in hepatic tumours has been described by a number of authors (BENDER & BLAU 1959, EPHRAIM 1962, COLLIN et coll 1964, CZERNIAK 1964, ACHAVAL et coll 1965) BENDER & BLAU investigated 49 cases with ^{131}I labelled rose bengal The results were correct in 44 cases, with 35 positive and 9 negative scintigrams The five wrong diagnoses included two over diagnoses and three missed expansive processes CZERNIAK scintigraphed 158 tumour cases with ^{198}Au or ^{131}I labelled rose bengal Expansive processes were demonstrated in 77 %, and 1 % false positives were found in a control series without tumours ACHAVAL et coll employed ^{131}I-labelled rose bengal in 36 cases of expansive liver processes Of these, twenty three were demonstrable, nine were suggestive of such lesion and four growths could not be demonstrated No false positives were observed in a control series consisting of normal subjects and patients with cirrhosis

Angiographic demonstration of hepatic tumours has usually taken the form of splenoportal phlebography (GVOZDANOVIC et coll 1953, BERGSTRAND & EKMAN 1957, STATTIN 1959) but recently angiography has come into use for the demonstration of primary neoplasms of the liver (BARTLEY et coll 1962 1967 BOIJSEN 1964, BOIJSEN & ABRAMS 1965) and metastases (BARTLEY et coll 1968)

The diagnostic value of the two methods are compared in the present paper

Methods Scintigrams were obtained with a Nukab apparatus employing a focusing collimator and producing 8 to 10 films at different discrimination levels Each scintigram has 20 scanned lines on an area of 40 cm×40 cm The scintigrams were made about 30 minutes after the intravenous injection of 0 25 mCi ^{198}Au Since the agent injected is taken up primarily by the reticulo endothelial system in the liver, an image of the liver alone may be obtained with appropriate discrimination If large parts of the hepatic parenchyma are damaged e g in cirrhosis or metastasis, the uptake in the liver is reduced absolutely as well as relatively An image of the spleen, again with suitable discrimination may also be obtained Despite this semiquantitative aspect, liver scintigraphy should be considered qualitative

Table 4

Results in 7 cases of liver metastases with tumour blood vessels

Angiography		Scintigraphy	
+	—	+	—
7	0	3	4

Table 5

Results in 8 cases of liver metastases without tumour blood vessels

Angiography		Scintigraphy	
+	—	+	—
5	3	5	3

Apart from the technique employed the diagnostic reliability of both methods depends on the location *and size of the expansive process* A diminution of intensity at the site of the gallbladder is normally present in scintigrams so that tumours in this region are more difficult to demonstrate than elsewhere in the liver With either method lesions in the left lobe are more difficult to demonstrate than those in the right lobe The series studied included a number of cases of diffusely disseminated and comparatively small hepatic metastases and two cases of solitary metastases 3 cm in diameter, too small to be demonstrated by scintigraphy the resolving power of the apparatus was inadequate False diagnoses were obtained by scintigraphy in two cases of hepatic cirrhosis The scintigram included a number of small deviations which were interpreted as related to tumours ACHAVAL et coll (1965) examined 17 cases of cirrhosis by scintigraphy They found a slower uptake and lower maximum than in normal subjects and in 15 instances noted a dappled pattern which they stated to be characteristic of cirrhosis The spleen in hepatic cirrhosis can often be discerned in the scintigram With increased experience of scintigraphy in hepatic cirrhosis it should be possible to obtain better and more reliable diagnostic results

The experience of the authors in a larger series of hepatic neoplasms examined with angiography (BARTLEY et coll) indicates that the selective technique is clearly superior to aortography The former method gives more complete filling of the blood vessels and newly formed tumour vessels not demonstrable by aortography have sometimes been observed The selective examination was unsuccessful in two of the three cases with a growth not seen at angiography In both a solitary metastasis was present near the surface of the liver and this location in itself may have been the reason why neither displacement of blood vessels nor any occlusion of the portal branches was revealed In at least one of these cases in which a very large mass was found at autopsy 3 months later the selective technique could perhaps have been successful In the other case the metastasis was 3 cm in diameter and, as blood vessels could not be demonstrated in the selective examination such a small neoplasm could probably not have been revealed by angiography Selective angiography was performed in the third case The liver was permeated by metastases measuring up to 2 5 cm although

Table 3

Results in 4 cases with primary hepatic tumours

	Angiography		Scintigraphy	
	+	−	+	−
With hepatoma 3 cases	3	0	3	0
With hemangioma 1 case	1	0	0	1

of, among other things, the abundance of blood vessels, all of these were diagnosed by angiography It was also possible to diagnose by angiography metastases from a carcinoid tumour, less than 1 cm in size Expansive processes in the liver could be diagnosed by scintigraphy in three of the seven cases In three of the four undiagnosed cases, the liver was permeated by metastases between 2 5 and 5 cm in diameter, and in the fourth case a solitary 3 cm large metastasis was present

Seven of the eight cases of non vascularized metastases to the liver were detected three by both methods, two by angiography and two cases by scintigraphy alone (Table 5) The last, undetected case turned out to be one of a solitary 3 cm large metastasis near the hepatic surface the tumour was not demonstrable by either method In one of the cases with negative angiography and positive scintigraphy, a 3 cm large metastasis was present in the right lobe, and the left lobe was almost completely replaced by malignant tissue In the other case, there was a solitary metastasis near the surface in the lateral part of the right lobe At autopsy 3 months later this metastasis was about 14 cm in diameter Selective examination was unsuccessful, and aortography was performed in two of the three cases in which angiography was negative

One of the two cases that were scintigraphically negative and angiographically positive had a 5 cm large mass close to the gallbladder, and the liver in the other case was permeated by metastases up to 2 5 cm in diameter

Discussion

A comparison of the two methods favours angiography Twenty seven of the 30 cases, 90 %, were diagnosed correctly The corresponding figures for scintigraphy were 20 out of 30 cases, 67 % The literature seems to contain no information on the reliability of angiography in the demonstration of expansive processes of the liver so no comparison with the present data is possible The results with scintigraphy are not in accord with some found in the literature (BENDER & BLAU 1959, CZERNIAK 1964) The discrepancy is probably due to the composition of the series rather than to an inferior technique

REFERENCES

ACHAVAL A TAUXE W N and GAMBILL E E Scintillation scanning of liver Mayo Clinic 40 (1965) 206

BARTLEY O EDLUND Y and HELANDER C G Angiografi vid maligna hematom (Swedish) Nord Med 68 (1962) 1606

— — — Angiography in primary hepatic carcinoma Acta radiol Diagnosis 6 (1967) 81

— HELANDER C G and STATTIN S Angiography in malignant liver tumours To be published in Acta radiol Diagnosis

BENDER M A and BLAU M Detection of liver tumours with I^{131} rose bengal Proc of Seminar by IAEA and WHO Vienna 1959

BERGSTRAND I and EKMAN C A Percutaneous lieno-portal venography Technique and complications Acta radiol 47 (1957) 269

BERNE E und JONSON U Ein magnetischer Analysator fur die quantitative Auswertung von Scintigrammen Nucl Med 1 (1959) 80

BOIJSEN F Rontgenologisk diagnostik av primara levertumorer (Swedish) Nord Med 7 (1964) 285

— and ABRAMS H L Roentgenologic diagnosis of primary carcinoma of the liver Acta radiol Diagnosis 3 (1965) 257

COLLIN F F LE ROY SIMS J and CAMERON J R Liver scanning and liver function tests J Amer med Ass 187 (1964) 111

CZERNIAK P Scanning study of 700 livers Evaluation of existing diagnostic procedures Proc Symp on Medical Radioisotope Scanning held by IAEA in Athens in April 1964

EPHRAIM K H Detection of liver tumours with colloidal radiogold A new method of high contrast photoscanning Amer J Roentgenol 87 (1962) 141

GVOZDANOVIC V and HAUPTMANN E Further experience with percutaneous lieno-portal venography Acta radiol 43 (1955) 177

— — NAJMAN F and OBERHOFER B Percutaneous splenic venography Acta radiol 40 (1953) 17

ÖDMAN P Percutaneous selective angiography of the coeliac artery Acta radiol (1958) Suppl No 159

SELDINGER S I Catheter replacement of the needle in percutaneous arteriography New technique Acta radiol 39 (1953) 368

STATTIN S Percutaneous lieno-portal venography in the demonstration of liver masses Acta radiol 52 (1959) 353

STIRRET I A YUHL E T and COSSEN B Clinical application of hepatic radioactivity surveys Amer J Gastroent 21 (1954) 310

not causing significant vascular displacement The portal branches were not manifestly abnormal Splenoportal phlebography might have provided the diagnosis

The most reliable angiography criterion of a hepatic neoplasm is the demonstration of newly-formed blood vessels, when such are evident even very small processes can be revealed Indeed, metastases less than 1 cm in diameter were demonstrated in one case The vessels sometimes have such characteristic appearances that the type of growth may be assessed Angiography is therefore superior to scintigraphy should such vessels be present

When the growths lack distinct newly formed vessels, the diagnostic criteria of vascular displacement and occluded portal branches are used The smallest tumour so observed was 2 5 to 5 cm in diameter For diagnostic purposes in growths poor in vessels, the two methods are thus quite comparable, and the results indicate that the methods complement each other

SUMMARY

A comparison of angiography and scintigraphy was made in 30 adults 11 without and 19 with a hepatic tumour The correct diagnosis was obtained by angiography in 90 per cent and by scintigraphy in 67 per cent of the cases Angiography is the more reliable method of diagnosing neoplasms with newly formed blood vessels but when such vessels are absent the two methods are roughly comparable The scope and limitations of the methods are discussed

ZUSAMMENFASSUNG

Ein Vergleich zwischen den Resultaten der Angiographie und der Scintillographie wurde an 30 Fallen 11 ohne und 19 mit einem Lebertumor vorgenommen In 90 % der Falle wurde mit der Angiographie eine korrekte Diagnose erhalten mit der Scintillographie nur in 67 % der Falle Angiographie ist die zuverlassigste Methode wenn der Tumor gefassreich ist in Fallen mit gefassarmen Tumoren sind die beiden Methoden ziemlich gleichwertig Die Anwendbarkeit beider Methoden und ihre Leistungsgrenzen werden besprochen

RÉSUMÉ

Les auteurs ont compare les resultats de l angiographie et de la scintigraphie hepatique chez 30 adultes dont 11 n avaient pas de tumeur et 19 avaient une tumeur hepatique Le diagnostic correct a ete obtenu par angiographie dans 90 % des cas et par scintigraphie dans 67 % L angiographie est la methode la plus fidèle pour le diagnostic des néoplasies qui contiennent des vaisseaux sanguins neoformes mais quand il n y a pas de vaisseaux neoformes les deux methodes sont en gros comparables Les auteurs examinent les indications et les limites de ces methodes

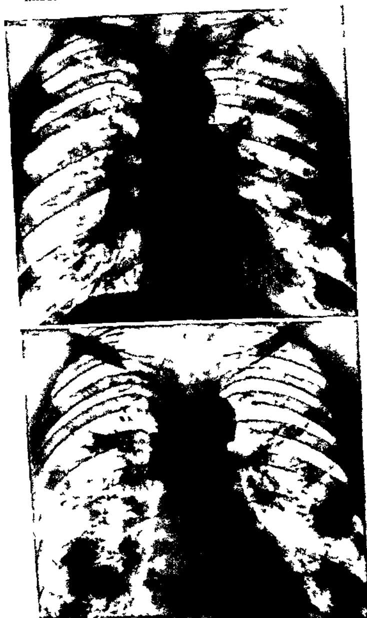


Fig 1 Case 1 Rheumatoid pneumoconiosis *Top view* Examination in 1940 Small disseminated nodules in both lungs with multiple larger rounded lesions in the lower zones *Lower view* Three years later Increase in size and number of the lesions

FROM THE DEPARTMENT OF RADIOLOGY AND THE CLINIC OF OCCUPATIONAL MEDICINE, KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

RHEUMATOID PNEUMOCONIOSIS (CAPLAN'S DISEASE)

A report on three cases encountered in Sweden

by

N P G EDLING, L OHLSON and Å SWENSSON

CAPLAN (1953) described a characteristic roentgenographic feature of the lungs in coal miners in Wales suffering from both pneumoconiosis and rheumatoid arthritis The peculiar rounded pulmonary nodules produced appearances easily distinguishable from those usual in progressive massive fibrosis The background of simple pneumoconiosis was often slight, or absent The typical findings were present in 13 of CAPLAN's 51 cases where the two conditions were associated MIALL et coll (1953) and CAPLAN et coll (1962) gave more extensive reports on the condition

Since the original paper of CAPLAN was published, several cases of a similar type have been reported among workers in dusty trades of different kinds The condition has also occurred in miners exposed to dust with a high quartz content (CLERENS 1953, CHRISTIAENS et coll 1954, VAN DER MEER 1954 PETRY 1954, CAMPBELL 1958, CAPLAN et coll 1958 KANTOR & MORROW 1958, RICHARDS & BARRATT 1958, POSNER 1960 CHATGIDAKIS & THERON 1961, MORGAN 1961, SNOEK et coll 1965)

Usually only one case, or at the most a few cases, are mentioned in these

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a



b

Fig 2 Case 2 Rheumatoid pneumoconiosis. a) Small disseminated nodules in both lungs with larger rounded lesions in the upper zones b) Seven years later Increase in size and number of the lesion

lungs In 1943 (Fig 1) they had become much larger and had increased in number especially in the lower part of the right lung The general silicotic changes had also become more marked At this time the patient was still in good general condition and continued working He died of miliary pulmonary tuberculosis in 1945

The section revealed in addition to acute miliary tuberculosis large rounded nodules the cut surface of which corresponded to CAPLAN's description Microscopy however failed to yield unequivocal evidence of rheumatoid pneumoconiosis sufficient material for re-examination was not available

reports The syndrome thus seems to be rare This is confirmed by e g TARA et coll (1954), who found one case in 1 300 cases of silicosis, ROSMANITH & BRUCKNER (1961) with 57 cases in 15 000 miners heavily exposed to mixed dust, quite a number of whom presumably with incipient or slight silicosis, and VIGLIANI et coll (1963) with one case in 1 500 cases of silicosis

The low frequency may perhaps be due to diagnostic difficulties CAPLAN et coll (1958) emphasized that in advanced true pneumoconiosis the rheumatoid pneumoconiotic nodules may be mistaken for large silicotic or silico-tubercular lesions

According to CAPLAN, the well defined rounded nodules in the parenchyma range from 0 5 to 5 cm in diameter, the usual diameter being about 1 cm, they may occur in any part of the lungs but most frequently lie peripherally They may appear before, at the same time as, or after, the onset of arthritis symptoms There is no apparent relationship between the severity of the arthritis and the type and extent of the roentgenologic signs (CAPLAN 1953, GOUGH 1960) These often appear more suddenly than progressive massive fibrosis and always more rapidly than silicotic nodules of the same size Numerous new lesions are reported to have developed within a few months in some cases while other cases have consisted of a few fairly stationary lesions It is fairly common for cavitation or fibrosis to occur Calcification is also not uncommon, and in many instances the nodules ultimately coalesce to form progressive massive fibrosis Rounded nodules and other changes in the parenchyma often co exist

A full description of the pathology was given by GOUGH et coll (1955) Sections of the nodules revealed a characteristic concentric arrangement with lighter and darker zones, readily differentiated from the appearances of progressive massive fibrosis and classical silicosis The microscopic features were also typical The nodule consisted of active inflammation with macrophages and frequently polymorphonuclear leucocytes and central necrosis as well Some of the macrophages contain dust, and when these disintegrate the dust is deposited and produces the dark zones

Roentgenologic appearances suggesting rheumatoid pneumoconiosis have been encountered in Sweden in three cases These had been exposed for many years to dust containing silica

Case reports

Case 1 Male born 1900 had worked in a mine between 1915 and 1945 Roentgen examination in 1937 revealed disseminated small nodular changes in both lungs as in simple pneumoconiosis and a rounded nodule about 1 cm in diameter in the left lung At subsequent examinations this latter gradually increased in size

In 1940 (Fig 1) several rounded nodules of about the same size were present in both



a



b

Fig 2 Case 2 Rheumatoid pneumoconiosis. a) Small disseminated nodules in both lungs with larger rounded lesions in the upper zones. b) Seven years later Increase in size and number of the lesions.

lungs In 1943 (Fig 1) they had become much larger and had increased in number especially in the lower part of the right lung The general silicotic changes had also become more marked At this time the patient was still in good general condition and continued working He died of miliary pulmonary tuberculosis in 1945

The section revealed in addition to acute miliary tuberculosis large rounded nodules, the cut surface of which corresponded to CAPLAN's description Microscopy however failed to yield unequivocal evidence of rheumatoid pneumoconiosis sufficient material for re-examination was not available



Fig 3 Case 2 Varying roentgenographic appearances in upper part of the left lung a) Examination one year after the *one shown in fig 2b b) A further year later c) Eleven days later*

Case 2 Male born 1902 had worked in a foundry between 1917 and 1958 He had had no symptoms of rheumatoid arthritis but the Rose agglutination test strongly suggested the presence of latent rheumatoid affection In 1949 (Fig 2a) roentgenography revealed silicotic changes of stage I and several rounded nodules 0 5 to 1 cm in diameter situated peripherally in the upper parts of both lungs The next roentgenologic examination was made in 1956 (Fig 2b) Some of the nodules had coalesced into one large rounded infiltration on each side The one on the left side contained a small cavity Some of the small changes had vanished and some new ones had developed During the following years a few more nodules appeared but the distribution on the whole remained constant

The smaller nodules increased uniformly in size whereas two large nodules varied considerably in size and shape On several occasions these contained cavities especially the one on the left side (Fig 3 a—c) The patient always remained in good general health apart from slight dyspnoea No evidence of tuberculosis

Case 3 Male born 1908 had worked in a mine between 1926 and 1951 No abnormality was noted at roentgen examination before 1950 then changes suggesting simple pneumoconiosis category I were apparent In 1951 concomitant with the onset of rheumatoid arthritis two nodules about 1 cm in diameter appeared in the right lung During the following year numerous new lesions developed and generally increased in size a cavity was present in one of the nodules in 1953

During the following two years the appearances changed rapidly from one examination to another (Fig 4) While on the whole the size and number of the lesions increased one single lesion might be in the form of an infiltrating mass with fluid contents at one ex



a



b

Fig. 4 Case 3 Rheumatoid pneumoconiosis. a) Small disseminated nodular and linear lesions with *multiple* rounded infiltrations in the parenchyma the latter are filled with air or fluid b) Three months later Many of the cavities are altered in appearance due to redistribution of air and fluid



Fig. 3. Case 2. Varying roentgenographic appearances in upper part of the left lung. a) Examination one year after the one shown in fig. 2b. b) A further year later. c) Eleven days later.

Case 2. Male, born 1902, had worked in a foundry between 1917 and 1958. He had had no symptoms of rheumatoid arthritis but the Rose agglutination test strongly suggested the presence of latent rheumatoid affection. In 1949 (Fig. 2a) roentgenography revealed silicotic changes of stage I and several rounded nodules 0.5 to 1 cm in diameter situated peripherally in the upper parts of both lungs. The next roentgenologic examination was made in 1956 (Fig. 2b). Some of the nodules had coalesced into one large rounded infiltration on each side. The one on the left side contained a small cavity. Some of the small changes had vanished and some new ones had developed. During the following years a few more nodules appeared but the distribution on the whole remained constant.

The smaller nodules increased uniformly in size, whereas two large nodules varied considerably in size and shape. On several occasions these contained cavities, especially the one on the left side (Fig. 3 a—c). The patient always remained in good general health apart from slight dyspnoea. No evidence of tuberculosis.

Case 3. Male, born 1908, had worked in a mine between 1926 and 1951. No abnormality was noted at roentgen examination before 1950, then changes suggesting simple pneumoconiosis category I were apparent. In 1951, concomitant with the onset of rheumatoid arthritis, two nodules about 1 cm in diameter appeared in the right lung. During the following year numerous new lesions developed and generally increased in size; a cavity was present in one of the nodules in 1953.

During the following two years the appearances changed rapidly from one examination to another (Fig. 4). While on the whole the size and number of the lesions increased, one single lesion might be in the form of an infiltrating mass with fluid contents at one ex-

and eosinophilic infiltration However, the roentgenologic and clinical course, as well as the laboratory findings in each of the present cases, exclude the possibility of any of these conditions as a cause of the lung changes Rounded lesions in cases of rheumatoid arthritis without silicosis seem to be extremely rare

The etiology of the lung changes in rheumatoid pneumoconiosis is still obscure The pneumoconiotic component seems to be essential for this special type and course of reaction It seems possible that a specific vulnerability of the lungs exists in individuals suffering from both silico is and rheumatic disease It may be that the presence of the dust has a pathoplastic influence so that the reactivity of the pulmonary tissue to dust is increased by the collagen disease The appearances at microscopy of the nodule in rheumatoid pneumoconiosis is essentially different from that of silico is The silicotic nodule is a collagenous structure with a tendency to hyalinization while the rheumatoid process consists of necrotic collagen with rings of deposited dust

SUMMARY

Three cases of silicosis with lung changes of the type CAPLAN found in South Wales coal miners suffering from both pneumonoconiosis and rheumatoid arthritis are reported The clinical course and the roentgen findings are di cu sed

ZUSAMMENFASSUNG

Drei Fal e mit Lungenveranderungen *ahnlich dem Typ von Lungensilikose* kombiniert mit rheumatischer Gelenkerkrankung wie sie von CAPLAN in Sud Wales bes hrieben wurde werden berichtet. Der klinische Verlauf und das Rontgenbild werden erortert

RÉSUMÉ

Les auteurs presentent trois cas de silicose pre entant des lesions pulmonaires du type CAPLAN trouvees chez des mineurs de charbon des Galles du Sud atteints a la fois de pneumoconiose et de polyarthrite rhumatoide Ils etudient l evolution clinique et les signes radiologiques de ces cas

REFERENCES

CAMPBELL J A A case of Caplan s syndrome in a boiler scaler Thorax 13 (1958) 177

CAPLAN A Certain unusual radiological appearances in the chest of coal miners suffering from rheumatoid arthritis Thorax 8 (1953) 29

— COWEN E D H and GOUGH J Rheumatoid pneumoconiosis in a foundry worker Thorax 13 (1958) 181

— PAYNE R B and WITHEY J J A broader concept of Caplan s syndrome related to rheumatoid factors. Thorax 17 (1962) 205



Fig. 5. Case 3. a) Examination four weeks after the one shown in fig. 4b. b) Eleven days later. A large cavity has developed in the upper part of the left lung. Variation in the distribution of air and fluid.

amination or a cavity containing air at another (Fig. 5 a—b). Laboratory tests for tuberculosis were negative. The patient had diabetes mellitus which might have explained the strong tendency to cavity formation. The patient died in 1957. No autopsy.

Discussion

It is evident that the pulmonary features of the three cases are in close accord with the characteristics described by CAPLAN. As in other cases reported in the literature, the pneumoconiosis was caused by dust rich in silica. Case 3 ran the most spectacular course. The lesions exhibited a strong tendency to cavity formation, possibly due also to the presence of diabetes mellitus. There were no calcifications. Only one of the three cases had symptoms of rheumatoid arthritis, the presence of latent rheumatoid affection in a second case seemed to be unequivocal from the laboratory examination. One of the patients (Case 2) is still alive, the further course of the roentgenologic changes and of the laboratory findings are being followed.

Similar rounded lung changes naturally may develop in other conditions such as tuberculosis, malignant metastases, multiple cysts, benign lymphogranulomas,

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ANGIOGRAPHY IN PRIMARY HEPATIC TUMOURS IN CHILDREN

by

MARIQUITA FREDENS

Primary malignant hepatic tumours in children are rare but their recognition is nevertheless of importance since improvements in surgical techniques have made treatment possible. Children appear to tolerate partial hepatectomy better than adults and because hepatic growths are often late in forming metastases the prognosis is usually better (FISH & McCARY 1966, ISHAK & GLUNZ 1967).

The two main histologic types of tumour are hepatocellular carcinomas and cholangiocellular carcinomas, the former being more common than the latter. The hepatocellular carcinomas are also called malignant hepatoma or hepatoblastoma, depending on the degree of maturity of the tumour cells, although considerable variation may occur in different parts of a single tumour (McDONALD 1967). The tumours may be divided into three groups according to their distribution: solitary, multiple nodular and diffuse.

The diagnosis of a hepatic neoplasm is difficult because the symptoms and laboratory findings present no particular features. Slight anaemia, loss of weight and palpable abdominal masses are common, jaundice is rare. Liver biopsy is only sometimes conclusive. Radioisotope scanning of the liver may afford some information regarding the localization and boundaries of the lesion (JOHNSON

From the Department of Radiology (Director Prof Gregers Thomsen), Rigshospitalet, the University Hospital of Copenhagen, Denmark. Presented at the Fifth Annual Meeting of the European Society of Pediatric Radiology in Hamburg May 1968. Submitted for publication 8 July 1968.

CHATGIDAKIS C B and THERON C P Rheumatoid pneumoconiosis (Caplan s syndrome) A discussion of the disease and a report of a case in a European Witwatersrand gold miner Arch environm Hlth 2 (1961), 397

CHRISTIAENS L, BALGAIRIES E, FOLBERT P et coll Le syndrome de Caplan Collinet A propos de 6 observations Arch Mal prof 15 (1954) 546

CLERENS J Silicose pulmonaire et rheumatisme ou syndrome de Collinet Caplan Arch belges Méd soc 11 (1953) 336

GOUGH J Rheumatoid pneumoconiosis *In* Proc of the pneumoconiosis Conference Edited by Orenstein J & A Churchill Ltd London 1960

— RIVERS D and SEAL R M Pathological studies of modified pneumoconiosis in coal miners with rheumatoid arthritis Thorax 10 (1955) 9

KANTOR M and MORROW C S Caplan s syndrome A perplexing pneumoconiosis with rheumatoid arthritis Amer Rev Tuberc 78 (1958) 274

MIALL W E CAPLAN A COCHRANE A L et coll An epidemiological study of rheumatoid arthritis associated with characteristic chest X ray appearances in coal workers Brit Med J 11 (1953) 1231

MORGAN W K C Caplan s syndrome Ann intern Med 55 (1961) 667

PETRY H Silikose und Polyarthritis Ein Beitrag zur Pathogenese entzundlicher Gelenker krankungen Arch Gewerbepath Gewerbehyg 13 (1954) 221

POSNER L Pneumoconiosis in makers of artificial grinding wheels including a case of Caplan s syndrome Brit J industr Med 17 (1960) 109

RICHARDS A G and BARRATT G Rheumatoid lung changes associated with asbestosis Thorax 13 (1958) 185

ROSMANITH J et BRUCKNER I Syndrome de Caplan chez les mineurs du bassin d Ostrava Karvina Pracov Lék 14 (1961) 70

SNOLK W I RAAB T en ALLELMAN A C Silicose na primair chronisch reuma syndrom van Caplan Ned T Geneesk 109 (1965) 11

TARA S CAVIGNEAUX A et LEPLACE Y Le syndrome de Caplan Arch Mal prof 15 (1954) 12

VAN DER MEER C Pneumoconiose en rheumatoid arthritis Ned T Geneesk 98 (1954) 3539

VIGLIANI E C BERNIS P e GAMBINI G Fattori reumatoidi e pneumoconiosis Med d Lavoro 54 (1963) 241

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The two main histologic types of tumour are hepatocellular carcinomas and cholangiocellular carcinomas, the former being more common than the latter The hepatocellular carcinomas are also called malignant hepatoma or hepatoblastoma depending on the degree of maturity of the tumour cells although considerable variation may occur in different parts of a single tumour (MCDONALD 1967) The tumours may be divided into three groups according to their distribution solitary multiple nodular and diffuse

The diagnosis of a hepatic neoplasm is difficult because the symptoms and laboratory findings present no particular features Slight anaemia, loss of weight and palpable abdominal masses are common jaundice is rare Liver biopsy is only sometimes conclusive Radioisotope scanning of the liver may afford some information regarding the localization and boundaries of the lesion (JOHNSON

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& GROSSMAN 1965) Angiography of the hepatic artery is also of considerable help in establishing the diagnosis and for obtaining further detailed information (BOIJSEN & ABRAMS 1965, BARTLEY et coll 1967, MCDONALD 1967, YU 1967)

Material and Methods Five children between the ages of 4 weeks and 14 years with primary hepatic tumours were subjected to angiography during 1966 and 1967 In four of these, a catheter was introduced through the femoral artery into the aorta, either percutaneously or by exposure of the femoral artery The tip of the catheter was placed at the level of the celiac artery and contrast medium (about 1 ml/kg bodyweight of Urografin 60 % or Conray 400) was injected with a Gidlund Elema pressure syringe Serial films were obtained in a p and lateral projections with a roll film changer In one case, a catheter was placed in the inferior vena cava and 2 ml/kg bodyweight of Urografin 76 % were injected The examination was then continued with cinematography over a period of 30 seconds at the rate of 12 exposures per second The contrast medium was visible in the aorta and the hepatic artery in the late phase No complications have arisen in connection with the angiographic examinations Selective angiography or splenoportal phlebography were not performed in any of the cases

Case reports

Case 1 Girl aged 14 years was admitted following a year of dyspepsia vomiting and moderate loss of weight A mass protruded in the upper part of the abdomen

Eleven months before admission explorative laparotomy in another hospital had revealed a large mass in the liver biopsy was negative The tumour was considered inoperable but because of good general condition the patient was transferred for further investigation

A barium meal examination disclosed marked displacement forwards of the stomach Cholegraphy indicated displacement of the common hepatic duct and urography revealed delayed excretion of the left kidney Liver scanning suggested a tumour in the left hepatic lobe

Marked displacement of the hepatic artery downwards was demonstrated at aortography The artery was dilated and its intrahepatic branches were stretched and displaced in a large part of the liver In the late arterial phase several irregular tumour vessels and accumulation of contrast medium in the neoplasm were observed There were no signs of arteriovenous shunting through the tumour (Fig 1)

A large growth of the left hepatic lobe was found at operation An attempt at removal was made but copious bleeding from the infiltrated inferior vena cava could not be arrested The patient died on the table the tumour was a hepatoma and measured 14 cm × 15 cm × 12 cm At autopsy cirrhosis of the left hepatic lobe and metastases were noted in the retroperitoneal lymph nodes The kidneys were normal

Case 2 Boy aged 11 months who for a few months had had anorexia and failed to gain weight The liver was enlarged Explorative laparotomy in another hospital disclosed a mass in the liver Biopsy produced heavy bleeding and it was concluded that the neoplasm was a haemangioma only hepatic cells and vessels were distinguished



Fig 1 Case 1 Hepatoma of the left hepatic lobe a) A p b) lateral. Slight displacement of the aorta to the left marked displacement and widening of the hepatic artery several tumour vessels are seen

The patient was transferred for further investigation Cholegraphy was normal *Aortography* disclosed a small hepatic artery with normal branches arising from the *celiac artery* and supplying the left hepatic lobe A wide hepatic artery arose from the superior mesenteric artery and supplied the right lobe and a large tumour within it The tumour was *extremely vascular and the vessels* were typical The tumour was stained with contrast medium and arteriovenous *shunting* was *present* (*Fig* 2)

At operation, a tumour 11 cm × 10 cm × 8 cm in size was removed from the right hepatic lobe *Unfortunately* cardiac arrest developed at the end of the operation and the patient died on *the table* Autopsy *showed the* left hepatic lobe to be normal and no metastases were seen The histologic diagnosis was *hepatoma*

A re examination of the biopsy specimen from the first operation proved the appearances to be identical with those at the final microscopic examination

Case 3 Boy aged 18 months was admitted with precocious development of the sex organs over a period of one month The genitalia resembled those of a boy of about 12 years voice deep and rough *The boy was otherwise* in good condition bodyweight 14 2 kg height 84 cm bone *development of hands was that of* a 2 year old the liver was enlarged and a hard bulging mass lay in the left lobe *urinary excretion* of pituitary gonadotropin (9 mouse units per day)

Roentgen *examinations of the* skull and the pituitary fossa were normal A hormone producing tumour of the liver was considered probable

Aortography disclosed a small *accessory hepatic* artery arising from the superior mesenteric artery and supplying the right *hepatic lobe with a dilated* hepatic artery from the celiac artery to the left lobe Some of the intra hepatic branches of the left lobe were *displaced*

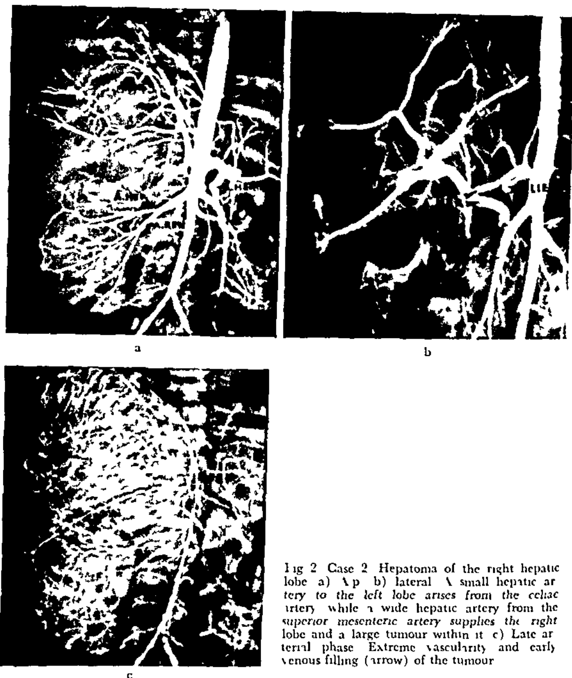
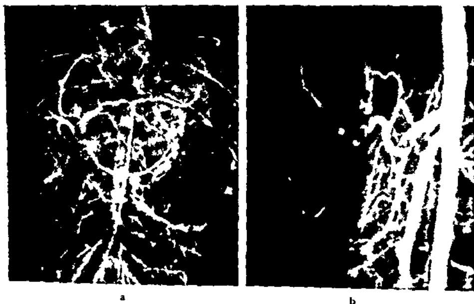


Fig 2 Case 2 Hepatoma of the right hepatic lobe a) A p b) lateral A small hepatic ar*tery to the left lobe arises from the celiac artery while a wide hepatic artery from the superior mesenteric artery supplies the right* lobe and a large tumour within it c) Late arterial phase Extreme vascularity and early venous filling (arrow) of the tumour

and stretched around a mass with a few but typical tumour vessels There was some accumulation of contrast medium within the tumour but no arteriovenous shunting was demonstrated (Fig 3)

At operation a 12 cm × 6 cm × 6 cm large tumour in the left lobe of the liver was removed There was no evidence of metastases and the extirpation was considered radical The patient survived and was well at the control examination one year later The hormone



a b

Fig 3 Case 3 Hormone producing hepatoblastoma of the left hepatic lobe a) A p of late arterial phase b) lateral Widening of the hepatic artery with displacement and stretching of branches of the left lobe tumour vessels are seen in the lateral projection (*arrows*)

excretion was normal and the genital development had been halted The histologic *diagnosis* was *hepatoblastoma*

Case 4 Girl nearly 7 years old was admitted with anaemia hepatomegalia and ascites that had *developed over* a period of about 2 months Three months before admission she had sustained a *moderate degree* of abdominal trauma in falling from her bicycle At first it was supposed that she had a haematoma of the liver *following rupture* of a vessel but the progressive *anaemia and* the gradual lowering of her general condition eventually suggested malignant disease The liver was palpable 8 cm below *the costal* margin the collateral abdominal venous system was prominent

On roentgen examination the right hemidiaphragm was found to be *raised* Cholegraphy *revealed* delayed excretion in normal hepatic ducts The liver *scan* was considered normal Aortography indicated displacement of the hepatic artery *downwards* and to the left. The intrahepatic branches were markedly displaced and stretched *around* a non vascular zone *in the* middle of the liver a few irregular vessels suggesting tumour vessels were demonstra*ted but* no arteriovenous shunting was visible The angiographic diagnosis was either a haematoma or a partially cystic tumour *of the liver* (*Fig* 4)

Laparotomy *revealed* a large cystic tumour containing blood and behind it a solid mass was penetrating the liver between the right and left lobes *infiltrating* the diaphragm The case was inoperable and the patient died 33 days *later* At autopsy about 1 400 ml of ascitic fluid was present the weight of the liver was 3 420 g *and its size* 30 cm × 26 cm × 10 cm The hepatic neoplasm was largely necrotic with representative changes *only* at the margins



a b

Fig 4 Case 4 Haemangioendothelial sarcoma of the liver a) A p b) lateral No widening of the hepatic artery but displacement and stretching of intrahepatic branches around a poorly vascularized mass only a few irregular vessels are visible in the upper posterior part of the liver

The appearances were those of a malignant endothelial sarcoma and not of carcinoma The growth was partially encircled by a dense fibrous pseudo capsule

Case 5 Boy aged 4 weeks was admitted because of poor weight gain for one week and a palpable mass in the abdomen A conventional film of the abdomen showed a mass containing small calcifications on the right side

Cinematography following contrast medium injection into the inferior vena cava indicated that it was not displaced although a hepatic vein was pushed upwards and laterally The aorta and the hepatic artery were visible in the late phase and in spite of the rather poor filling it was evident that several tumour vessels were present in the liver

Laparotomy revealed a large tumour of the right hepatic lobe the tumour was extirpated and there were no signs of metastases At control examination 5 months later which included abdominal aortography the patient had jaundice but there was still no evidence of metastases The patient was last seen 9 months after the operation and was then without symptoms

The weight of the tumour was 160 g the histologic diagnosis was hepatoblastoma

Results and Discussion

Four of the cases had hepatocellular carcinomas The tumour was situated in the right hepatic lobe in two cases and in the left lobe in the other two cases The literature on the subject suggests that the right lobe is mostly involved (Ishak & Glunz 1967)

The tumour in Case 1 developed in a cirrhotic liver this is common in adults but not in children (FISH & McCARY 1966 SORSDAHL & GAY 1967)

Case 3 was one of a histologically typical hepatoblastoma but produced hormones to cause precocious genital development This combination is rare and only a few cases are reported in the literature KOSENOW & FEIL (1967) collected six cases and added one of their own All were boys aged between 16 months and 3 years two of them were subjected to partial hepatectomy but none survived more than 15 months from the date the diagnosis was established The patient in our case was alive and in good condition when last seen 12 months after the operation

Case 4 was not one of hepatocellular carcinoma but of a haemangio-endothelial sarcoma of the liver The tumour probably represented a locus minoris resistentiae the moderate trauma caused bleeding into it the increasing haematoma producing the initial symptoms. Calcifications in hepatocellular carcinomas are not rare in children (MARGULIS et coll. 1956, SORSDAHL & GAY 1967) but were only present in one of the patients (Case 5)

The angiographic findings were conclusive in all the cases and were characteristic and uniform in the hepatocellular carcinomas Typical tumour vessels and accumulations of contrast medium within the tumours, as well as displacement and widening of the hepatic artery, were always demonstrated These conclusions are in complete agreement with those of BOIJSEN & ABRAMS (1965)

Angiography clearly indicated that the tumours were of the solitary type a fact confirmed at operation Angiography in Cases 2 and 3 also revealed that the hepatic lobe involved as well as the unaffected lobe were supplied from separate hepatic arteries a matter of importance of course from the surgical standpoint The endothelial sarcoma of Case 4 presented atypical angiographic appearances because the main part of the growth was cystic and without vessels Angiography was also valuable in this case however for the solitary lesion in the liver indicated operation which unfortunately came too late however

The value of angiography in primary hepatic tumours has been stressed among others by BOIJSEN & ABRAMS (1965) BARTLEY et coll (1967), YU (1967) McDONALD (1967) and ALFIDI et coll (1968) BOUCHIER & LESSOF (1964) pointed out the value of splenoportal phlebography while hepatic arteriography was considered more risky and the appearances often undistinguishable from those of cirrhosis

It is considered necessary to use arteriography in cases of probable primary hepatic tumour In young children it would seem that aortography should be sufficient for a satisfactory demonstration of the hepatic arteries and at the same time important information may be obtained about other abdominal vessels

SUMMARY

Five children with primary hepatic malignant tumour were subjected to angiography The findings proved of considerable value not only in establishing the diagnosis but also in obtaining information about pathologic features vascularization and the boundaries of the lesion Abdominal aortography appears to be the method of choice in young children

ZUSAMMENFASSUNG

Angiographie wurde an funf Kindern mit malignem Lebertumor vorgenommen Die Befunde waren wertvoll nicht nur fur die Diagnose sondern auch mit Hinsicht auf die pathologischen Verhaltnisse die Gefassversorgung und die Abgrenzung des Tumors Bei Kleinkindern scheint abdominale Aortographie ausreichend zu sein

RÉSUMÉ

L auteur a fait une angiographie a cinq enfants atteints de tumeur hepatique maligne primitive Les resultats de cet examen ont un intéret considerable non seulement pour établir le diagnostic mais aussi pour obtenir des renseignements sur la nature la vascularisation et les limites de la lesion L aortographie abdominale parait etre la méthode de choix chez les jeunes enfants

REFERENCES

ALFIDI R S RASTOGI H BUONOCORE E and BROWN C H Hepatic arteriography Radiology 90 (1968) 1136

BARTLEY O EDLUND Y and HELANDER C G Angiography in primary hepatic carcinoma Acta radiol Diagnosis 6 (1967) 81

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FISH J C and McCARY R G Primary cancer of the liver in childhood Arch Surg 93 (1966) 355

ISHAK K G and GLUNZ P R Hepatoblastoma and hepatocarcinoma in infancy and child hood Cancer 20 (1967) 396

JOHNSON P M and GROSSMAN M Radioisotope scanning in primary carcinoma of the liver Radiology 84 (1965) 868

KOSENOW W und FEIL G Sexuelle Frühreife durch primäres Lebercarcinom Hepatogenitales Syndrom Mschr Kinderheilk 115 (1967) 37

McDONALD P Hepatic tumours in childhood Clin Radiol 18 (1967) 74

MARGULIS A R NICE C S M and RIGLER L G The roentgen findings in primary hepatoma in infants and children Radiology 66 (1956) 809

SELDINGER S I Catheter replacement of needle in percutaneous arteriography new technique Acta radiol 39 (1953) 368

SORSDAHL O A and GAY B B Roentgenologic features of a primary carcinoma of the liver in infants and children Amer J Roentgenol 100 (1967) 117

YU C Primary carcinoma of the liver (hepatoma) Amer J Roentgenol 99 (1967) 142

FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF OLLE OLSSON),
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ANGIOGRAPHY IN WILMS' TUMOUR

by

J FOLIN

Wilms tumour (synonyms nephroblastoma embryoma adenosarcoma) is dysontogenetic Ninety per cent of the cases consist of children under 7 years of age (BELL 1950) and embrace 4 5 to 7 5 per cent of all having malignant renal tumours (DEMING 1963) According to the Manchester Childrens Tumour Register the annual incidence of Wilms tumour is approximately 6 cases per million children (PEARSON et coll 1964) The Swedish National Board of Health (1963) placed the annual incidence at 7 4 cases per million children (< 15 years) Wilms tumour has also recently been estimated from British national statistics to occur in at least 1 per 10 000 live births (COCHRAN & FROGGATT 1967)

The tumour is usually diagnosed at an examination performed for obscure abdominal distension or for abnormal fatigue vomiting and pain or though less often haematuria An early diagnosis is important from the point of view of therapy because the 5 year cure rate is higher when the condition is discovered within the first two years of life (e g GROSS & NEUHAUSER 1950 KINZEL et coll 1960 SUKAROCHANA & KIESEWETTER 1966) The tumour appears as a retroperitoneal mass involving one or though rarely both kidneys The kidney may

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SUMMARY

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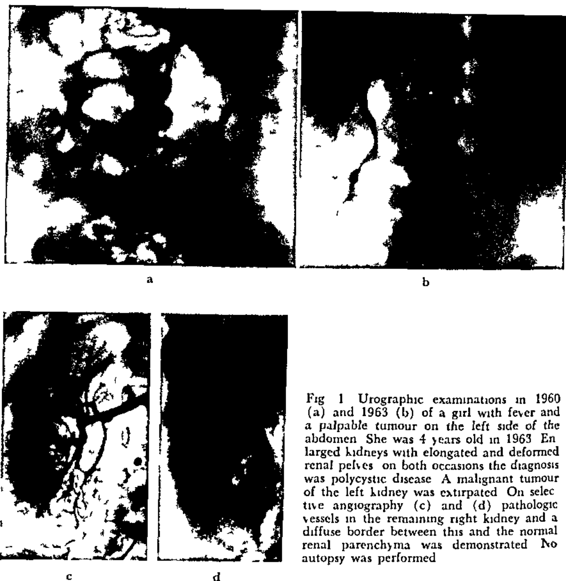


Fig 1 Urographic examinations in 1960 (a) and 1963 (b) of a girl with fever and a palpable tumour on the left side of the abdomen She was 4 years old in 1963 Enlarged kidneys with elongated and deformed renal pelves on both occasions the diagnosis was polycystic disease A malignant tumour of the left kidney was extirpated On selective angiography (c) and (d) pathologic vessels in the remaining right kidney and a diffuse border between this and the normal renal parenchyma was demonstrated No autopsy was performed

be enlarged, deformed or displaced, and calcifications occur in 12 per cent of all cases (Steinbach & Brown 1953) Urography, or in cases of non function of the kidneys pyelography, discloses deformation of the renal pelvis and sometimes hydronephrosis as prominent features Single or multiple cysts or multicystic disease and, in extrarenal conditions neuroblastoma, should be considered in the differential diagnosis The latter tumour may arise in the adrenal gland and then often so close to the kidney that the origin cannot be recognised urographically

Abeshouse (1957) collected data on 856 cases of Wilms tumour in only one case had *translumbar aortography* been performed, and it had not proved useful



Fig 2 Urography in a girl aged 4 years and 6 months who had pain and a large lump on the right side of the abdomen had shown a tumour of the right kidney with compression of the renal pelvis. At lumbar angiography (a) and (b) several vessels were seen to arise from the right renal artery Selective superior mesenteric angiography (c) revealed pathologic vessels from the right middle colic artery On selective coeliac angiography no evidence indicating that these vessels contributed to the blood supply of the tumour was obtained Operation and histologic examination revealed a Wilms tumour

OLLE OLSSON (1962), in a few cases examined with nephroangiography, found the angiographic features of Wilms tumour to be mainly the same as those of renal carcinoma HOPE et coll (1965) used translumbar aortography in one case to differentiate between intrinsic and extrinsic renal tumour McDONALD et coll (1968) recently published seven cases and FARAH et coll (1968) two cases of Wilms tumour examined with angiography

To assess the reliability of the angiographic diagnosis records and films of the cases of Wilms tumour that had been examined angiographically in our department were reviewed and analysed

Material and Methods Twenty three patients in all 11 boys and 12 girls had been operated upon for histologically verified Wilms tumour during the period 1951—1967 The mean age at the time of operation was about 4 years Angiography had been performed in eight of these cases

Thirteen of the twenty three patients died within 2 years One of the patients survived 3 5 years and one 5 5 years at operation these children were respectively 7 5 and 3 years of age The remaining eight patients are still living four of them in good health 5 7 8 and 14 years respectively after operation at which time

they were on the average about 1 year old The other four patients were operated upon less than 2 years before the present investigation The tumour was bilateral in four cases Urography was carried out in all cases except one The kidney was found to be functionless in six

Lumbar aortography was performed in five cases, two of the subjects were then 4 years old, two were 5 and one was 8 years old Selective angiography was performed in three cases, when the children were 1, 4 and 7 years old, respectively

Angiography was always preceded by urography In one case the affected kidney was silent and in another no excretion was observed until 24 hours later, excretion appeared normal in the other cases In two cases, both kidneys had been infiltrated by the growth At urography the lesions had been mis diagnosed as bilateral multicystic kidneys and polycystic disease, respectively, which had delayed the operation of one of the cases by 3 years (Fig 1) The filled renal pelvis was displaced, compressed and dilated and the calyces elon gated The tumour had not infiltrated the renal pelvis in any of the cases In none of the twenty two cases in which urography was performed could a diagnosis of malignancy be made by the method

The investigation was started with selective angiography in one case (in 1959) but since the catheter was large for the lumen of the artery the investiga tion was continued as lumbar aortography with the same catheter The tumour was about 7 cm in diameter In the other four cases examined with lumbar aortography the tumour was so large that it displaced the aorta In two cases (from 1966 and 1967) the examination was extended to include coeliac angio-graphy and, in the last case, also superior mesenteric angiography in order to determine whether the tumour was supplied by other vessels as well as the renal artery (Fig 2)

In the case mentioned above, in which the examination was started as selective angiography using a catheter with an end hole but continued as lumbar aorto graphy without exchanging the catheter for one with side holes the filling of the renal artery was unsatisfactory The examination revealed an expanding renal process but no pathologic vessels, puncture produced no signs of a cyst Some of the contents of the mass were therefore aspirated and proved by cytologic examination to be from a Wilms tumour This was confirmed at autopsy

In the other four cases examined with lumbar aortography and in the three remaining cases examined with selective angiography pathologic vessels of the type common in renal carcinoma in adults, i e vessels of irregular caliber, newly formed arteries, arteriovenous anastomoses (cf OLSSON 1962, Fig 154b and 154c, p 195), were apparent The pathologic vessels may sometimes be less evident, but the characteristic variation in caliber as well as a diffuse border



a



b



c



d

Fig 3 Urography (a) in a boy aged 16 months with haematuria and a palpable abdominal tumour An expanding process 4 cm by 4 cm in size in the upper pole of the right kidney the renal pelvis and calyces are displaced downwards Selective angiography (b) and in a later phase (d) showed pathologic vessels in a tumour diffusely outlined against the surrounding renal parenchyma Operation and histologic examination revealed a Wilms tumour in intact capsule (c) The patient is still alive 14 years after nephrectomy

between the tumour and healthy renal parenchyma are always present on close examination (Figs 1 and 3) Vessels other than the renal artery may also supply the tumour (Fig 2)

Discussion

KERR (1944) wrote 'Since the clinical diagnosis of malignant neoplasms of the kidney and renal region in children is fairly definite, the role of roentgenographic studies is chiefly confirmatory This view is incompatible with that of several other workers in the field Thus, ABESHOUSE (1957) stated that palpation, and urography or pyelography are the commonest diagnostic methods MELICOW & USON (1959) reported that 50 % of all palpable abdominal tumours in children arise in the urinary tract and that one third of these tumours are malignant (Wilms tumour) According to these authors, the use of intravenous and retrograde pyelography in children has contributed greatly to the earlier and more accurate diagnosis of all renal lesions, including Wilms' tumour This view is shared by various other authors (RICHES 1959, KINZEL et coll 1960, PEARSON et coll 1964, HOPE & BORNS 1965, BAERT et coll 1966 and WESTRA et coll 1967) LALLI et coll (1966) in a carefully investigated series of 31 cases found that the urographic findings were compatible with the diagnosos of nephro blastoma in all cases except one This does not, however, mean that the changes evident at urography were unequivocal, i e that they allowed a definite diagnosis of malignancy No matter whether the calyces are deformed or dilated, or whether the kidney is silent, it is less easy in children than in adults to make a diagnosis of a malignant renal tumour from such changes Neither urographically nor pyelographically can Wilms tumour be distinguished from other tumours, cysts or multicystic disease, as pointed out by HOPE et coll (1965) In children, according to these authors, most lesions of a kidney in which there is no function will prove to be cases of so called multicystic kidney, although sometimes a large non functioning kidney may prove to be the seat of a Wilms tumour HOPE et coll suggested cavography for the differential diagnosis, obstruction of the inferior vena cava would then indicate involvement by extension of a Wilms tumour

Since Wilms tumour is sometimes bilateral, and since multicystic tumours may be unilateral, it often is not possible by urography or pyelography to distinguish between these two conditions The one kind of lesion may therefore be mistaken for the other, as has been the case in the present material

A definite diagnosis of renal malignancy may, however, be made by angiography, and particularly by selective angiography The degree of vascularity of the nephroblastoma varies considerably, but it is usually high This has sometimes been believed to be the explanation of why calcifications are so rare in Wilms tumour (HOPE & BORNS 1965) while in poorly vascularized neuroblastomas the reverse occurs However, also Wilms tumour may sometimes be poor in vessels Selective angiography is therefore the method of choice in children

and adults to obtain optimal filling of the vessels without superimposition of irrelevant vessels (FOLIN 1967) Most *neuroblastomas are supplied mainly by* the suprarenal arteries although this sometimes also occurs in Wilms tumour Angiography will not therefore always differentiate between a Wilms tumour and a neuroblastoma but may determine whether a given tumour is benign or malignant An exception to this rule is a hamartoma if richly vascularized (VIAMONTE JR et coll 1966, FALKMER et coll 1968 GREEN 1968) Again it is not always possible to distinguish between these two forms of growth at operation (KAY et coll 1966)

But for the above exception then angiography can be used to avoid the risks of misdiagnosis inherent in urography and exemplified above in the literature (SNYDER et coll 1962 LALLI et coll 1966) ABESHOUSE (1957) who reported an erroneous diagnosis of Wilms tumour in 32 per cent of 856 cases warned against regarding every abdominal tumour in children below 10 years of age as a Wilms tumour This is a common error with unnecessary operations as a result KERR & GILLIES (1944) *described a unilateral polycystic kidney which was first treated* with roentgen radiation and then removed in the belief that it was a Wilms tumour

Since the tumours are not seldom bilateral selective angiography of both kidneys is always indicated even when urography demonstrates a change on one side only In the event of bilateral involvement, angiography will help to decide whether at least part of one kidney can be saved

SUMMARY

In twenty two cases of histologically verified Wilms tumour an expansive renal process was demonstrated at urography but no diagnosis of malignancy could be made Angiography was performed in eight of the cases and definite signs of a malignant growth was then demonstrated.

ZUSAMMENFASSUNG

In zweiundzwanzig Fallen von histologisch bestatigten Wilms Tumoren wurde mit Urographie ein raumfordender Prozess diagnostiziert aber keine Malignitat konnte nachgewiesen werden In acht von diesen Fallen wurde mit Angiographie die Malignitat festgestellt

RÉSUMÉ

L urographie a mis en evidence une lesion expansive rénale dans vingt deux cas de tumeur de Wilms vérifiée histologiquement bien qu on n ait pas pu *demontrer* la malignite L angiographie dans huit cas a cependant donné des signes de tumeur maligne.

REFERENCES

ABESHOUSE B S The management of Wilms tumor as determined by national survey and review of the literature J Urol 77 (1957), 792

BAERT L, VERDUYN H and VEREECKEN R Wilms tumors (nephroblastomas) report of 57 histologically proved cases J Urol 96 (1966), 871

BELL E T Renal diseases Second edition Lea & Febiger Philadelphia 1950

COCHRAN W and FROGGATT P Bilateral nephroblastoma in two sisters J Urol 97 (1967) 216

DEMING C L Tumors of the kidney *In* Urology Edited by M F Campbell Vol 2 p 895 W B Saunders Co Philadelphia and London 1963

FALKMER S JUNGHAGEN P S, RAIS O and SALTZMAN G F Hamartoma (lipoangiomyoma) of the kidney Acta radiol Diagnosis 7 (1968) 417

FARAH J and LOFSTROM J E Angiography of Wilms s Tumor Radiology 90 (1968) 775

FOLIN J Angiography in renal tumours Acta radiol (1967) Suppl No 267

GREEN G J The radiology of tuberous sclerosis Clin Radiol 19 (1968) 135

GROSS R E and NEUHAUSER B D Treatment of mixed tumours of the kidney in childhood Pediatrics 6 (1950) 843

HOPE J W and BORNS P Radiologic diagnosis of primary and metastatic cancer in infants and children Radiol Clin N Amer 3 (1965) 353

KAY S PRATT C B and SALZBERG A M Hamartoma (leiomyomatous type) of the kidney Cancer 19 (1966) 8125

KERR H D and GILLIES C L The urinary tract The Year Book Publishers Chicago 1944

KINZEL R C MILLS S D, CHILDS Jr D S and DE WEERD J H Wilms s tumor a review of 47 cases J Amer med Ass 174 (1960) 1925

LALLI A F AHSTROM L ERICSSON N O and RUDHE U Nephroblastoma (Wilms tumor) Radiology 87 (1966) 495

McDONALD P and HILLER H G Angiography in abdominal tumours in childhood with particular reference to neuroblastoma and Wilms tumour Clin Radiol 19 (1968) 1

MELICOW M M and USON A C Palpable abdominal masses in infants and children a report based on a review of 653 cases J Urol 81 (1959) 705

OLSSON O Roentgen examination of the kidney and the ureter *In* Encyclopedia of urology Edited by C E Alken V W Dix H M Weyrauch and E Wildbolz Vol 1 p 1 Springer Verlag Berlin Gottingen Heidelberg 1962

PEARSON D DUNCAN W B and POINTON R C S Wilms tumours — a review of 96 consecutive cases Brit J Radiol 37 (1964) 154

RICHES E New growths of the kidney Scot med J 4 (1959) 217

SNYDER W H HASTINGS T N and POLLOCK W Retroperitoneal tumours *In* Pediatric surgery Edited by C D Benson W T Mustard M M Ravitch et coll Vol 2 p 860 Year Book Medical Publishers Chicago 1962

STEINBACH H L and BROWN R I Retroperitoneal tumours in children Calif Med 78 (1953) 263

SUKAROCHANA K and KILSEWETTER W B Wilms tumor Factors influencing long term survival J Pediat 69 (1966) 747

WESTRA P KIEFFER S A and MOSSER D G Wilms tumor A summary of 25 years of experience before actinomycin D Amer J Roentgenol 100 (1967) 214

VIAMONTE Jr M RAVEL R POLITANO V and BRIDGES B Angiographic findings in a patient with tuberous sclerosis Amer J Roentgenol 98 (1966) 723

FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR ULF RUDHE)
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RENAL PELVIS APPEARANCES IN NEPHRO AND NEUROBLASTOMAS

Diagnostic value of true lateral projections

by

OLE EKLOF and ERIK LUNDIN

BODIAN & OCKENDEN (1965) found that about a quarter of a large series of malignant neoplasms in infancy and childhood collected from 1925 to 1962 originated in the retroperitoneal organs Most of these were nephroblastomas (Wilms tumour) and neuroblastomas a finding consistent with general experience (SNYDER HASTINGS & POLLACK 1962 HOPE BORNS & KOOP 1963 and others) With the improvement in therapeutic resources in recent years especially as regards nephroblastomas accurate roentgenologic preoperative diagnosis has assumed increasing importance

True lateral films of the upper urinary tract have been included by several authors among the measures recommended for improving the results of the radiologic examination of choice namely intravenous urography (SHERMAN & LEAMING 1953 CRESSON & PILLING 1959 SNYDER et coll HOPE et coll and CAFFEY 1967) No systematic analysis of the experiences gained would seem to have been published One aim of the present study was to assess the value of the

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Fig 1 Small left side nephroblastoma with separation elongation and compression of the upper calyces

true lateral projection as an aid in the differential diagnosis in cases of nephro and neuroblastomas, the chief purpose being to examine the changes in the renal pelvis occurring in these conditions

Material and Methods A review was made of all the cases of nephro and neuroblastomas examined and treated during the period 1952—1967 Cases were considered suitable for the study if acceptable intravenous urograms were avail able, including at least one lateral film of the upper urinary tract, histologic reports were at hand for all those chosen

The criteria were fulfilled by 36 cases with a total of 37 tumours all but six of which had been included in the larger series that had previously been examined by LALLI, ÅHSTROM, ERICSSON & RUDHE (1966) and EKLOF & GOODING (1967), six were new cases A histologic diagnosis of nephroblastoma was made in 20 cases with a total of 21 tumours and of neuroblastoma in 16 cases In three of the former, the involved kidney was not functioning but the cases were included since this feature is of some diagnostic significance

One case of nephroblastoma had bilateral tumours and both are reported



Fig Large right side neuroblastoma compressing and displacing the renal pelvis in a latero-caudo-anterior direction with simultaneous rotation of the kidney The tumour extends over the midline to cause lateral displacement and rotation of the contralateral kidney Slight dilatation of the left pelvis the left ureter is curved laterally (→) left side paravertebral growth at the Th 7 to 10 level (→)

Another with nephroblastoma had previously been examined and given treatment at another hospital for nephroblastoma in the contralateral kidney As the films from the earlier examination were not available at the review, only the tumour examined by us and diagnosed 18 months later was included in the series

The cases were analysed to determine the diagnostic significance of anteroposterior displacement of the renal pelvis and to assess relationship to other displacement as well as its deformation with or without functional impairment of the kidney

Results

Nine of the nephroblastomas in the series were on the right and twelve on the left side the latter including three cases with no renal excretion on the affected side Six neuroblastomas were on the right and ten on the left side

There was some deformation in all the cases of nephroblastoma in which the involved kidney was functioning and in all but one case a displacement of the renal pelvis as well No displacement of the renal pelvis was evident in the case



Fig 3 Left side nephroblastoma *displacing the pelvis in a mediocaudo anterior direction* Intrarenal growth of the tumour causes local dilatation and compression with simultaneous displacement of a minor calyx towards the surface of the kidney (→)

of a small nephroblastoma in the cranial pole of the left kidney although separation and elongation of the upper calyces were noted (Fig 1)

Similar changes in the renal pelvis were observed in fourteen cases of neuroblastoma in which the neoplasm arose from the suprarenal gland or part of the sympathetic chain near the kidney On the other hand, one of two neuroblastomas that originated in the distal part of the sympathetic chain produced only deformation and displacement of the bladder and the other of the bladder and the ipsilateral ureter Two nephroblastomas and one neuroblastoma grew over the midline, deforming and displacing the contralateral renal pelvis (Fig 2)

Anterior displacement of the renal pelvis sometimes considerable (Figs 2 and 3), was observed in fourteen cases of nephroblastoma and seven cases of neuroblastoma At least one other component of displacement, cranial, caudal medial or lateral, was also present Displacement in one or more of these directions unaccompanied by anterior displacement sometimes occurred The renal pelvis



Fig 4 Right side nephroblastoma with displacement of the pelvis towards the posterior surface of the kidney to cause local alternating dilatation and compression of the calyces (→) The ureter is encircled

was compressed in a posterior direction in two cases of nephroblastoma and one case of neuroblastoma (Fig 4) (For anatomical reasons no true *posterior* displacement is possible) The main direction of displacement in all cases *in which* it occurred is indicated in Fig 5 A most striking feature was that medial displacement of the renal pelvis was present in about a third of the nephroblastoma cases but in none of the neuroblastoma cases in which lateral displacement of the *renal pelvis* was more common (Fig 6) This was often combined with marked displacement of one renal pole (Fig 7) *This type of* displacement resulted in rotational malposition of the kidney about one or more axes a feature not *observed in the nephroblastoma* cases

The deformation of the renal pelvis on the affected side occurred in the nephroblastomas *in three main forms* with various combinations (1) separation of a few calyces (Fig 1) or groups of *calyces or, in* extreme cases, all the elements of the renal pelvis (Fig 4) (2) various degrees of dilatation, either local or more often involving the whole renal pelvis (Figs 3 and 4), and (3) compression and *marked displacement* sometimes combined with dilatation of the whole renal pelvis *(Fig 8) The* two latter types of deformation occasionally occurred in neuroblastomas although compress*ion and* elongation of the calyces unaccompanied by dilatation of part of or the whole of the renal pelvis was most common (*Figs* 2 *and* 7)



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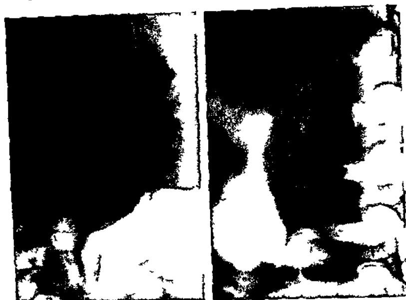


Fig 6 Left side neuroblastoma producing lateral displacement of the kidney especially of the cranial pole The tumour encircles the pelvo-ureteric junction probably with invasion of the ureter which is curved laterally

therapy is less effective in neuroblastomas it should however be introduced after operation (ÅHSTRÖM 1968)

The true lateral projection as well as the common standard projections were used to evaluate the displacement of the renal pelvis Lateral films of the upper urinary tract have been included since the middle of the 1950s at first as a complement in selected urologic cases but more recently as a routine measure at every intravenous urography The projection has proved of value in following the course of the ureters, and especially in the analysis of conditions within the pelvo-ureteric and ureterovesical junctions Assessment of involvement of the renal pelvis and of the direction and extent of the growth in the examination of retroperitoneal masses has been rendered easier

Some form of displacement or deformity or both of the renal pelvis occurred in all cases of nephroblastoma with excretion on the affected side The same was true in all cases of neuroblastoma where the tumour arose in the suprarenal gland or the renal part of the sympathetic chain. STEINBACH & BROWN (1953) who obviously did not use true lateral films found distortion of the intrarenal structures in about three quarters of their cases The difference between the findings in the two series may however be due not only to differences in the

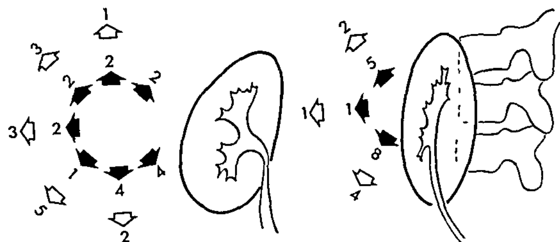


Fig 5 Main direction of displacement of the pelvis in 18 nephro (filled arrows) and 14 neuroblastomas (empty arrows)

The kidney with the nephroblastoma was in three cases not functioning, owing to compression of the pelvo ureteric junction, invasion of the renal vein, or a combination of the two In none of the neuroblastoma cases, however, was the function affected

Discussion

Since many of the abdominal masses in children particularly in infants, originate in the retroperitoneal organs it is obvious that urography should always be carried out The most common expansive process is hydronephrosis, but both nephro and neuroblastomas occur often enough to warrant serious consideration Retroperitoneal masses of other genesis are fairly uncommon

Nephroblastomas arise in the kidney and are surrounded at first by a pseudocapsule consisting of stretched atrophic renal parenchyma Only at a fairly late stage is there invasion of the renal pelvis, renal veins and the retroperitoneal tissues Neuroblastomas, again, appear either in the suprarenal medulla or in the sympathetic chain, with a considerable tendency to early infiltration of the surrounding organs (AREY 1963, BODIAN & OCKENDEN) These differences in growth should in theory give rise to characteristic urographic appearances

It is clinically important, where possible, to make the differential diagnosis before operation The risk of haematogenic spread by surgery is considered to be particularly great in nephroblastoma, and if the diagnosis has been made with reasonable confidence these cases are given pre operative chemotherapy Chemo-

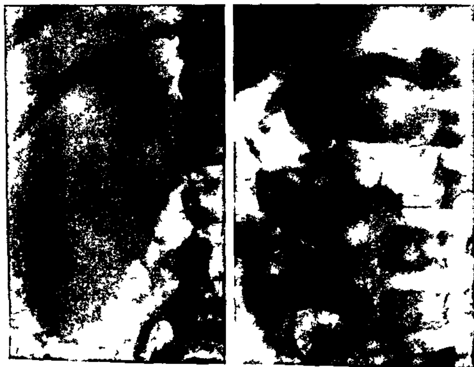


Fig 8 Large right side nephroblastoma in the lower pole of the kidney displacing the pelvis in a cranio-anterior direction The ureter is curved to the left moderate general dilatation of the pelvis due to compression by the tumour at the pelvo-ureteric junction.

with medial (mediocranial or mediocaudal) than with lateral (laterocranial or laterocaudal) displacement in nephroblastomas While the latter component was usually small or moderate, the medial displacement was sometimes considerable for instance in two cases the renal pelvis and in one case the ipsilateral ureter were displaced over the midline

No medial displacement of the renal pelvis was recorded in the cases of neuroblastoma. The laterocaudal and sometimes laterocranial displacement typical of this condition was usually combined with the characteristic rotational malposition mentioned by e g SHERMAN & LEAMING HOPE et coll CAFFEY

The deformation of the renal pelvis was more informative from the diagnostic aspect Three main variants could be distinguished in nephroblastomas. In the first separation of the various elements of the renal pelvis through intrarenal growth gave rise alternatively to locally dilated or compressed calyces (Figs 3 and 4) Marked partial displacement of the renal pelvis towards the kidney

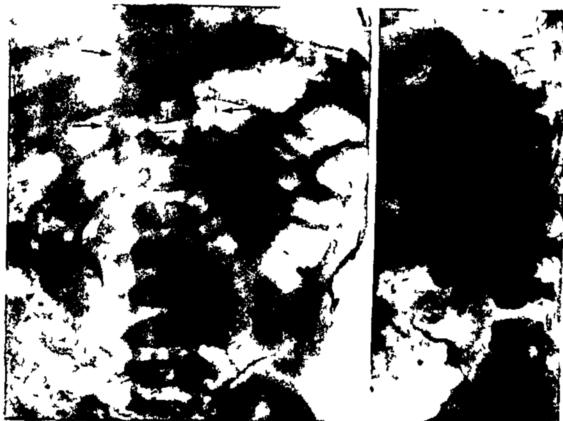


Fig 7 Large left side neuroblastoma with typical rotation and displacement of the kidney in a laterocaudo anterior direction Compression of the renal pelvis but general architecture retained bilateral paravertebral growth at the Th 7 to L 1 level with extensive areas of floc culent calcification (→)

examination technique but also to the composition of the series STEINBACH & BROWN s material may have included several cases of neuroblastoma that arose in the sympathetic chain far enough from the kidneys for them not to be affected More remarkable is the fact that a quarter of the cases of nephroblastoma in which the kidney was functioning exhibited no changes in the renal pelvis In the present series, the involvement of the renal pelvis was generally much more marked in the cases of nephroblastoma, which is also in line with general ex perience

The renal pelvis was displaced forwards in about three quarters of the nephro blastomas and one half of the neuroblastomas This direction of displacement has therefore on its own no obvious differential diagnostic significance However when the displacement as was most common, had several components, a closer analysis revealed characteristic features for the two forms of neoplasm

Forward displacement of the renal pelvis was rather more frequently combined

tion with separation or elongation of a few calyces around a small tumour, and sometimes by the absence of renal function on the affected side The possibility of *hydronephrosis and multicystic kidney* must however have been eliminated

A neuroblastoma is suggested by lateral (laterocranial or laterocaudal) and possibly anterior displacement of the renal pelvis Asymmetric displacement of the affected kidney may result in its rotation about one or more of its axes and produce moderate deformation of the pelvis this may result from its compression or sometimes, by its slight dilatation

SUMMARY

Changes evident at urography have been analysed in a series of 21 nephro- and 16 neuro blastomas The roentgenologic differential diagnosis is discussed Special consideration is given to the value of the true lateral projection which it is suggested is of particular importance in assessing the extent of the expansive process

ZUSAMMENFASSUNG

Die Rontgenbefunde bei Urographie in einer Serie von 21 Fallen von *Nephro* und 16 Fallen von Neuroblastome werden analysiert Die rontgenologische Differenzialdiagnose wird besprochen Besonders betont wird der Wert einer wirklich lateralen Projektion wenn es sich *um die Auswertung der Ausdehnung des krankhaften Prozesses handelt*

RÉSUMÉ

Les auteurs ont analysé les modifications évidentes de l urographie dans une serie de 21 nephroblastomes et de 16 neuroblastomes Ils étudient le diagnostic différentiel radiologique de ces affections Ils examinent specialement la valeur de la projection en vrai profil qui a leur a is a une importance particuliere pour determiner l extension de la tumeur

REFERENCES

AREY J B Abdominal *masses in infants and children* Pediat Clin N Amer 10 (1963) 665

AUSTROM L Personal communication (1968)

BODIAN M and OCKENDEN B G Aspects of cancer in childhood *In* Recent advances in paediatrics Edited by D J Gairdner Churchill Ltd London 1965

CAFFEY J Pediatric X ray Diagnosis 5th edition Year Book Medical Publishers Chicago 1967

CRESSON S L and PILLING G P Renal tumors Pediat. Clin N Amer 6 (1959) 473

EKLOF O and GOODING Ch A Paravertebral *widening in cases* of neuroblastoma. Brit J Radiol 40 (1967) 358

surface with simultaneous compression and dilatation was sometimes present (Fig 3) In another variant a fairly large mass at one renal pole caused compression and marked anterocranial (Fig 8) or anterocaudal displacement of the generally dilated renal pelvis The third type with a fairly small peripheral tumour produced a deformity essentially the same as that evident in solitary cysts of the adult kidney, with elongation and separation of the calyces of a single calyceal group (Fig 1) Moderate dilatation due to malignant growth around the pelvo-ureteric junction also occurred in some of the neuroblastomas General compression, with the normal architecture of the renal pelvis largely retained, was however the commonest deformation (Figs 2 and 7)

Extension of the tumour over the midline occurred in both types of growth but it was only in the case of nephroblastomas that bilateral tumours were observed Another feature, which was recognized in three cases of nephroblastoma but in none of the neuroblastomas, was the absence of renal excretion on the side of the tumour It may be mentioned that EKLOF & GOODING in a large series of neuroblastoma cases found none in which renal function was entirely absent on the affected side

The differential diagnosis between hydronephrosis and a multicystic kidney is of primary importance in the case of a non functioning kidney In the former, which is common, excretion is sometimes delayed although it is usually possible to outline the renal pelvis by prolonged urography, where this is not successful the problem will probably be solved by reflux in micturition urethrocystography If neither excretion nor reflux is obtained, the possibilities of hydronephrosis or multicystic kidney remain, the latter lesion is, however rare (LALLI 1967) A definitive diagnosis with the aid of renal angiography is almost always possible (McDONALD & HILLER 1968)

Conclusions

The true lateral projection together with conventional urographic views constitutes a valuable means of assessing the extent of a retroperitoneal expansive process Alone, however, it fails to contribute essentially to the differentiation between nephro and neuroblastomas A careful analysis of the observations in the present series enabled certain criteria for the two types of neoplasm to be established

The presence of nephroblastoma (Wilms tumour) is suggested by medial (mediocranial or mediocaudal) anterior displacement of the renal pelvis, by separation of its various elements, with or without displacement towards the surface of the kidney, as well as raising or depression of the pelvis with its concomitant anterior displacement, compression and dilatation by local deforma

FROM THE DEPARTMENTS OF ROENTGEN I (DIRECTOR PROF O BARTLEY) AND SURGERY I (DIRECTOR PROF L E GELIN), SAHLGRENSKA SJUKHUSET, GOTHENBURG, AND THE COAGULATION LABORATORY (DIRECTOR PROF I M NILSSON) ALLMÄNNA SJUKHUSET MALMÖ SWEDEN

PLATELET ADHESION AND THROMBUS FORMATION ON VASCULAR CATHETERS IN DOGS

by

BO JACOBSSON SVEN ERIK BERGENTZ and ULF LJUNGQVIST

Vascular catheterisation is now widely used in diagnostic techniques (angiography blood analysis blood pressure recording) and in therapeutics (artificial cardiac pace makers intravenous and intraarterial drip)

The most common serious complication of vascular catheterisation is thromboembolism Though the causal mechanism is not properly understood there is evidence that the risk varies with the area of the outer surface of the intra vascular part of the catheter This suggests thrombus formation to be stimulated by some reaction of the blood to the surface of the catheter (JACOBSSON & SCHLOSSMAN 1969a)

It has been demonstrated in vitro that platelets adhere to the surface of a catheter and aggregate (JACOBSSON 1969a) The initial phase of thrombus formation is characterised by a similar reaction of platelets to the vessel wall HUGUES 1962 ZUCKER & BORRELLI 1962 HOVIG 1963, OWREN 1964, MUSTARD et coll 1967) It was therefore thought worthwhile to investigate if platelets

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HOPE J W, BORNS Patricia F and KOOP C E Diagnosis and treatment of neuroblastoma and embryoma of the kidney Radiol Clin N Amer 1 (1963) 593

LALLI A F Multicystic kidney disease Radiology 89 (1967) 857

— AHSTROM L ERICSSON N O and RUDHE U Nephroblastoma (Wilms tumor) Urographic diagnosis and prognosis Radiology 87 (1966), 495

McDONALD P and HILLER H G Angiography in abdominal tumours in childhood with particular reference to neuroblastoma and Wilms tumour Clin Radiol 19 (1968) 1

SHERMAN R S and LEAMING R The roentgen findings in neuroblastoma Radiology 60 (1953) 837

SNYDER W H HASTINGS T N and POLLOCK W Retroperitoneal tumors *In* Pediatric surgery Edited by Benson Mustard Ravitch et coll Year Book Medical Publishers Chicago 1962

STEINBACH H L and BROWN R F Retroperitoneal tumors in children Roentgen diagnosis Calif Med 78 (1953) 263

Table

Quotients between radioactivity per gram of deposits and radioactivity per gram of the whole blood

Dog No	Deposits on outer wall of catheter in		Deposits aspirated from catheter in brachial artery
	Femoral artery	Femoral vein	
1	50		2
	90		
2	75		7
	50		75
			20
			40
3	10	20	
	20		
4		105	
		60	
5	65	55	75
6	80	65	10
			10
7			25
			20

withdrawn 20 cm The activity of the still indwelling half and that of the half withdrawn through the incision in the vessel were then measured separately

Experimental series II (five dogs) A catheter with an open end hole was passed 5 to 10 cm into the brachial artery The catheter was rinsed intermittently with physiologic saline despite this it was sometimes plugged by material which was aspirated The radioactivity per gram of the plugs was calculated and compared with that of the whole blood from the same animal The catheters were not examined for mural deposits

Results

The clots always weighed more than half as much as the whole blood samples from which they had formed

Experimental series I Firm red grey deposits (see accompanying figure) readily distinguished from blood clots were found on all the catheters. The deposits weighed all together 0 01 to 0 6 g per catheter The radioactivity per gram of the deposits was 10 to 105 times higher than that of the whole blood (see Table) It was not possible to demonstrate any variation with the type of vessel catheter-

adhere to catheters passed into arteries and veins in vivo and if so, if this might be responsible for thromboembolism occurring after catheterisation

Material and Methods Seven mongrel dogs were used Three of the dogs had some hours previously in an unrelated experiment been subjected to trauma on the thighs by means of a padded hammer

The following catheters were employed

		Inner diameter	Outer diameter
Polythene (Clay-Adams PE 160)		1 1 mm	1 6 mm
Radiopaque polythene (Kifa, Odman-Ledin)	red	1 2	2 2
» » » »	green	1 2	2 4
Teflon (Habia)		1 1	1 6

The platelets were labelled in vitro with ^{51}Cr (250 μCi) by Foss ABRAHAMSEN's (1968) modification of the method of AAS & GARDNER (1958) The activity was measured with a 3″ NaI well crystal (Autowell II Picker)

Experimental procedure The animals were anaesthetised with pentothal 2 to 3 days (six animals) or 6 days (one animal) after the platelets had been labelled The vessels to be used, the femoral or brachial artery or vein, were exposed, and one to three catheters (see Table) introduced for 10 to 40 cm The deposits formed on the outer wall (experimental series I) and inner wall (experimental series II) of the catheters were studied The relation between the weight of the whole blood, and the clot formed from it, during a period of 2 to 12 hours, was determined in ten samples

Experimental series I (six dogs) When catheters with sealed end holes had been in position for 30 to 70 minutes the dogs were given a lethal dose of the anaesthetic The arteries and veins with the indwelling catheters were exised en bloc after the animal had died (Nos 1 to 5) The vessels were then slit up, the catheters carefully lifted out, and mural deposits, if any, were weighed The vessels of the sixth dog were opened before the animal had died The deposits were not studied for any covariation in weight with the type of catheter or with the time the catheter had been in the vessel Measurements were made of the total activity of the catheters, and the radioactivity per gram of the mural deposits and of the whole blood was calculated

The fate of the mural deposits on withdrawal of the catheter was studied in two of the dogs A radiopaque polythene catheter (Kifa red on one occasion and green on another) was passed 40 cm into the femoral artery on each side Just before the animal was given the lethal dose of anaesthetic the catheters were

mediately proximal to the puncture hole was a collar of deposits on the outer wall of the catheter (see Figure) These deposits had evidently been wiped off from the withdrawn part of the catheter The radioactivity i e the number of platelets on the part of the catheter that was left in the vessel, was 400 to 1 900 times that of the half that had been withdrawn

Experimental series II The radioactivity per gram of the thrombus material aspirated from the indwelling catheters was 2 to 75 times higher than that of the whole blood, but was somewhat lower than that of the deposits on the wall of the catheter in experimental series I

Discussion

The concentrations of platelets in the deposits on the outer as well as the inner surface of the catheters were higher than that in the blood The differences were far too large to be ascribed to clot retraction The deposits thus contain large amounts of platelets and must have been thrombi initiated by platelet adhesion to the catheter wall

It has been shown in vitro that the contact of platelets with the naturally occurring substance collagen (ZUCKER & BORRELLI 1962) or with the surface of a catheter (JACOBSSON 1969a) may induce platelet adhesion and aggregation Collagen and plastic surfaces provoke a similar reaction in vivo The exposure of collagen in an injured vessel as well as the passage of a catheter into a blood vessel may stimulate thrombus formation

The experimental conditions (anaesthesia operative procedure to expose the vessels and choice of experimental animal) cannot have played a decisive role in the formation of the thrombi on the catheters since thrombi have been demonstrated on the walls of catheters placed in human blood vessels. In a preliminary investigation of seven randomly selected subjects in whom a catheter had been left in a vessel for 1 to 3 weeks thrombi were regularly revealed on the outer wall of the catheter at angiography (JACOBSSON & SCHLOSSMAN 1969b)

It is well known that thrombi after percutaneous catheterisation for angiography are localised at the puncture site and emboli distal to it This is readily explained by the finding that thrombi formed on the wall of the catheter are wiped off on withdrawal of the catheter through the vessel wall

The reaction of the blood to contact with synthetic materials has received extensive attention especially in the field of cardiovascular surgery where a number of synthetic compounds have been tried for their suitability as artificial valves and vessels The use of such materials is however often followed by thromboembolism (GOTT 1966) It appears reasonable to assume that thromboembolism following insertion of a cardiovascular implant may be due to the

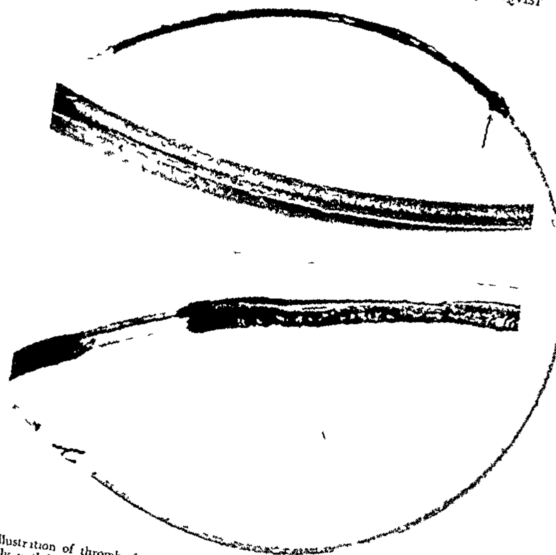


Illustration of thrombi formed after vascular catheterisation The long coiled catheter was partly withdrawn through the vessel wall and a collar of thrombi (arrow) formed at the junction between the withdrawn and indwelling parts The two shorter catheters show thrombi formed on the outer walls

used, with the type of catheter used, or with the time the latter had been in the vessel No difference in activity was found between deposits from catheters from animals in which only veins or arteries or both had been catheterised neither did deposits from traumatised animals differ from the others Furthermore, the activity was largely the same whether the vessels had been opened before or after the animal had died

The withdrawn part of the catheter was free from gross deposits but in

mediately proximal to the puncture hole was a collar of deposits on the outer wall of the catheter (see Figure) These deposits had evidently been wiped off from the withdrawn part of the catheter The radioactivity i e the number of platelets on the part of the catheter that was left in the vessel was 400 to 1 900 times that of the half that had been withdrawn

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adhesion of platelets to the implant and the consequent formation of thrombi The testing of the suitability of these materials has usually been confined to determination of the clotting time of blood or plasma in tubes and clot formation on intracardial implants (GOTT 1966)

The present investigation revealed that measurement of the coagulation time is not sufficient to estimate the suitability of a synthetic material for vascular implants and catheters It was found that platelets adhere to such materials and initiate thrombus formation, its prevention requires the use of some material to which platelets do not adhere or of some agent capable of reducing platelet adhesiveness The latter alternative has been tried with good results (JACOBSSON 1969b)

SUMMARY

The causal mechanism of thromboembolism following vascular catheterisation was investigated in dogs It was found that platelets adhere to the catheters and that thrombi are formed On withdrawal of the catheter through the vessel wall the thrombotic deposits are wiped off and remain in the blood stream

ZUSAMMENFASSUNG

Versuche an Hunden wurden vorgenommen um den Vorgang bei der Entstehung von Thrombose und Embolie bei Gefasskatheterisierung zu studieren Es wurde festgestellt dass Thromben durch Adhasion von Blutplattchen am Katheter verursacht werden konnen Wenn der Katheter vom Blutgefass herausgezogen wird werden die Thromben abgestreift und verbleiben im Blutstrom

RÉSUMÉ

Les auteurs ont etudie sur des chiens le mecanisme des thromboembolies apres cathéterisme vasculaire Il semble que les plaquettes adherent au catheter in vivo et produisent des thrombus Quand on retire le cathéter a travers la paroi vasculaire les depots thrombotiques se detachent et partent dans le courant sanguin

REFERENCES

AAS K A and GARDNER F H Survival of blood platelets labelled with chromium 51 J Clin Invest 37 (1958) 1257

FOSS ABRAHAMSEN A A modification of the technique for ^{51}Cr labelling of blood platelets giving increased circulating platelet radioactivity Scand J Haemat 5 (1968) 53

GOTT V The causes and prevention of thrombosis on prosthetic materials J Surg Res 6 (1966) 274

HOVIG T Release of a platelet aggregating substance (adenosine diphosphate) from rabbit blood platelets induced by saline extract of tendons Thrombos Diathes haemorrh (Stuttg) 9 (1963) 264

HUGUES J Accolement des plaquettes aux structures conjonctives perivasculaires Thrombos Diathes haemorrh (Stuttg) 8 (1962) 241

JACOBSSON B (a) Platelet adhesion and aggregation following contact between blood and vascular catheters in vitro To be published in Scand J Haemat

— (b) Effect of pretreatment with dextran 70 on platelet adhesiveness and thromboembolic complications following percutaneous arterial catheterisation To be published in Acta radiol Diagnosis

— and SCHLOSSMAN D (a) Thromboembolism of leg following percutaneous catheterisation of femoral artery for angiography Predisposing factors Acta radiol Diagnosis 8 (1969) 109

— — (b) Angiographic investigation of formation of thrombi on vascular catheters To be published in Radiology

MUSTARD J F GLYNN M F NISHIZAWA E E and PACKMAN M A Platelet surface interactions relationship to thrombosis and hemostasis. Fed Proc. 26 (1967) 106

OWREN P A The hemostatic plug Thrombos Diathes haemorrh (Stuttg) (1964) Suppl No 13 p 325

ZUCKER M B and BORRELLI J Platelet clumping produced by connective tissue suspensions and by collagen Proc Soc exp Biol (N Y) 109 (1962) 779

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SIALOGRAPHY

New application of the subtraction technique

by

B. LILIEQUIST and U. WELANDER

Sialography is a well established procedure for examination of the salivary glands and was introduced in the middle 1920's independently by BARSONY (1925), USLENGHI, and CARLSTEN (1926). All used oily contrast media. As early as 1913, however, ARCELIN had injected bismuth emulsion into Wharton's duct prior to radiography for a calculus.

Previous reports concerning the technique of sialography mainly dealt with the choice between different kinds of contrast media and the technique of filling the ductal systems. Only a few considerations of the proper projections appear in the literature (ROSE 1950, HETTLER & LAUTH 1961, GARUSI 1964, OLLERENSHAW & ROSE 1950, 1956).

The contrast medium used in sialography nowadays is almost always water soluble, the oily suspensions previously used having been abandoned. This has led to a modification of the technique in so far as the injection can be performed through thin tubing introduced into the main duct of the gland to be examined (GULLMO & BOOK-HEDERSTROM 1958, LIVERUD 1959, DREVATTNE & STIRIS 1964, GARUSI 1964, HETTLER & LAUTH 1961, RUBIN et coll. 1955).

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Fig 1 Parotid sialography subtraction view The small accessory glands along Stenson s duct are well outlined



Fig 2 Submandibular sialography subtraction technique lateral view Small accessory glands distally along Wharton s duct

A problem in sialography besides the choice of a suitable contrast medium, has been to obtain correct projections of the different salivary glands and their ductal systems As these formations are in close contact with adjacent bone structures the use of the subtraction technique is obviously of value and the procedure of sialography should therefore be adapted accordingly HIFLSCHER & FRENKEL (1967) mentioned the use of the subtraction technique in sialography and noted that details might be better identified They failed however to change their method of sialography

The demonstration of the ductal system and its ramifications as well as the size and shape of the gland and the identification of accessory glands are of equal importance (OLLERENSHAW & ROSE 1951) The true size of a salivary gland, at least the parotid is difficult to assess from roentgen films produced by conventional methods unless the gland is overfilled with contrast medium this is not desirable and should be avoided OSMER & PLEASANT (1966) however have described a technique of distention sialography in which they recommend a large amount of contrast medium in order to outline the whole gland A great number of the endings of the smallest ductal ramifications may be traced in well exposed lateral views although many of them may be obscured by overlapping bone structures The medial part of the parotid gland is seldom well defined in a p views Accessory glands along Stenson s and Wharton s ducts are often very small They will be incorrectly projected with any technique and therefore difficult to identify unless special procedures such as the subtraction technique be applied (Fig 1)

The topographic relationships of the submandibular gland are more favour

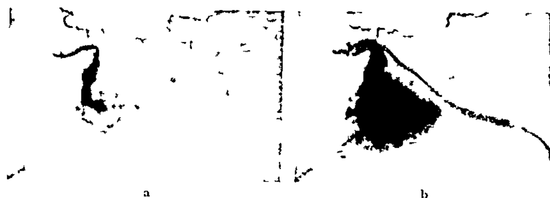


Fig 3 Sublingual sialography subtraction technique lateral views a) Ductal system b) The whole gland

able than those of the parotid gland Thus, the whole gland can be projected free from adjacent bone structures if a proper projection is chosen, the subtraction technique then gives no more information than a well exposed conventional roentgen film The subtraction technique is however useful for a study of the main duct which is partly overlapped by the mandible, as are the accessory glands anteriorly (Fig 2)

The sublingual glands are seldom the object of a sialographic examination They are difficult to examine because they have short, discrete ducts, which are not easily cannulated The examination may however sometimes be achieved with success, especially when the sublingual glands empty into Wharton's duct, the subtraction technique then produces excellent views of the ductal system as well as of the gland (Fig 3)

Technical considerations Cannulation of the main duct of any salivary gland is best performed with polythene tubing drawn out into a fine tip The calibre of the tubing should be chosen to suit the size of the main duct All ducts can easily be cannulated, especially if their openings are widened with a probe, and there is no need for a wire as guide (according to LIVERUD) nor for a metal cannula at the end of the catheter (GULLMO & BOOK HEDERSTROM) The tip of the tubing should not be cut sharp but drawn out after heating, this will prevent any risk of damage to the mucosa The procedure is painless, any pain during cannulation being a sign of damage to the duct and necessitating postponement of the examination for one or two days

As the opening of the duct is usually narrower than the main duct itself it will be occluded by the catheter so that a closed system will be formed Leakage of contrast medium through the opening into the mouth will only occur if the tubing is withdrawn from the duct in error or the tubing is of too small a calibre



Fig 4 Parotid sialography subtraction technique lateral view



Fig 5 Left parotid gland subtraction technique a p view The boundaries of the gland can be studied medially as well as laterally

The catheter may safely be left in position during the whole examination It is withdrawn for emptying studies of the gland as soon as the filling phase has been completed

We use Urografin 60 % as contrast medium 0 5 to 2 ml are usually enough for a proper evaluation of the ducts as well as of the size and shape of the gland The amount is varied dependent on which gland is to be examined being less in the submandibular than in the parotid gland A wide Wharton s duct may, however hold a large volume of contrast medium

The projections recommended have varied in previous reports An oblique lateral view has usually been favoured for the examination of both the parotid and the submandibular glands Oblique views have been chosen in accordance with the opinion that in this way the glands are most suitably projected free from overlapping bone structures this is however not necessarily the case The parotid gland which lies in the retromandibular fossa, consists of a larger superficial lobe and a smaller deep lobe connected by an isthmus. The two lobes and the isthmus invest the mandible in such a way that they cannot be projected free from it in lateral or a p views

The submandibular gland is smaller than the parotid gland and is partly lodged between the mandible and the floor of the mouth it projects downwards into the neck The gland can be projected free from the mandible in a true lateral view



Fig 6 Submandibular sialography lateral view The gland is projected free from the jaw

The oblique lateral view is in other respects unfavourable as it is inconvenient for the patient The cannulation of the duct must be performed with the patient in a different position, the tubing may therefore become dislodged from the duct opening during the positioning of the patient for the roentgen examination

Subtraction technique The use of the subtraction technique implies exposures of at least two films with the patient in exactly the same position This is most easily and conveniently achieved with the equipment used for carotid angiography Serial exposures can be made for both lateral and a p views with the patient in a relaxed position Cannulation of the ducts is also made more easy and there is no need to move the patient after the tubing has been placed in the duct of the gland

A suitable equipment is Mimer provided with AOT film changers for lateral and a p views With this unit, the head of the patient can be fixed in a correct position The first exposure is made with the catheter in situ and before any contrast medium has been injected The second exposure is made after injection of 0 5 ml contrast medium, and the third and final exposure follows after a further injection of 1 5 to 2 ml of the medium The same procedure is repeated for the a p views with the second AOT changer The cassette changers make it possible to choose beforehand a suitable program with any desired interval

The subtraction views may be produced photographically or electronically The technique of obtaining subtraction views is well known and will not be described in this communication (Ziedses des Plantes 1961) The photo graphic method is sufficient for practical purposes

The true lateral view has been recommended by Garusi who performed the whole examination with the patient seated A supine position is advantageous for the subtraction method, however, as blurring due to movement of the head may then easily be avoided (Fig 4) True lateral views of the parotid gland are also

favoured by OLLERENSHAW & ROSE who however preferred an oblique view of the submandibular gland A true lateral view can always be reproduced it also corresponds to the conventional views of the skeletal structures of the face, the relationship between the glands and their ducts and the adjacent structures are better demonstrated Special views can be added when necessary With the Mimer or with similar equipment, specific projections may be chosen with the aid of an image intensifier

Discussion

The use of the subtraction technique in sialography has proved successful Distal minute ramifications in the ductal system, as well as small accessory glands can be studied in detail even when overlapped by skeletal structures

The appearance of the parotid gland with the subtraction technique is demonstrated in Fig 2 The boundaries of the gland may be identified although they are partly overlapped by adjacent bone structures. Small accessory glands along the main duct are easily recognized Both the inner and the outer lobes of the gland as well as the isthmus may be defined in the a. p view (Fig 5) The submandibular gland can be examined without application of the subtraction technique (Fig 6) for with the chin of the patient raised the gland will be thrown clear of the mandible The subtraction technique is however of value for a study of the accessory glands as well as of Wharton s duct (Fig 2) This is particularly true when the examination is directed to the sublingual glands (Fig 3)

It is obvious from these examples that the subtraction technique applied to sialography will contribute to a proper estimation of the size and shape of the salivary glands and their ducts Conventional films are also obtained with this technique these are of the same high quality as those in conventional carotid angiography The suggested method of performing sialography may therefore be used with advantage even if facilities for employing the subtraction technique are lacking

SUMMARY

A technique for sialography holding several advantages over conventional methods is described *It allows application of the subtraction method* and optimal projections are easily achieved Positioning of the patient is simplified and cannulation is also facilitated

ZUSAMMENFASSUNG

Eine neue Technik fur Sialographie die wesentliche Vorteile gegenuber der gewohnlichen Technik erbietet, wird beschrieben Sie ermoglicht die Anwendung der Subtraktionsmethode und optimale Projektionen sind leicht erreichbar Die Lagerung des Patienten und die Einfuhrung der Kanule sind einfacher geworden

RÉSUMÉ

Les auteurs décrivent une technique de sialographie qui a plusieurs avantages sur les méthodes habituelles Elle permet d utiliser la technique de soustraction et de réaliser facilement les meilleures incidences La mise en place du malade est simplifiée et le cathétérisme devient moins difficile

REFERENCES

ARCELIN Quoted by RUBIN et coll (1955)

BARSONY TH Idiopathische Stenongangdilatation Klin Wschr 4 (1925) 2500

CARLSTEN D B *Lipiodolinjektion in den Ausführungsgang der Speicheldrüsen* Acta radiol 6 (1926) 221

DREVATTNE T and STIRIS G Sialography by means of a polyethylene catheter and water soluble contrast medium (Isopaque 75 %) Brit J Radiol 37 (1964) 1

GARUSI G F The salivary glands in radiological diagnosis Bibl Radiologica Fasc 4 S Karger Basel 1964

GULLMO A and BOOK HEDERSTRÖM G A method of sialography Acta radiol 49 (1958) 17

HETTLER M und LAUTH G Die gezielte Sialographie Fortschr Röntgenstr 95 (1961) 493

HIELSCHER W und FRENKEL G Diagnostische Konsequenzen der spezialisierten Röntgenuntersuchungsverfahren Dtsch zahnärztl Z 22 (1967) 171

LIVERUD K Sialographic technique with a polyethylene catheter Brit J Radiol 32 (1959) 627

OLLERENSHAW R G W and ROSE S S Radiological diagnosis of salivary gland disease Brit J Radiol 24 (1951) 538

— — Sialography A valuable diagnostic method Dent Radiol Photogr 29 (1956) 37

OSMER J C and PLEASANT J E Distention sialography Radiology 87 (1966) 116

ROSE S S Sialography in diagnosis Postgrad med J 26 (1950) 521

RUBIN PH BLATT I M HOLT J F and MAXWELL J H Physiological or secretory sialography Ann Otol 64 (1955) 667

USLENGHI J P Quoted by GARUSI (1964)

ZIEDSES DES PLANTES B G Subtraktion Thieme Verlag Stuttgart 1961

FROM ROENTGENDIAGNOSTIC DEPARTMENT I (DIRECTOR PROF O BARTLEY), SAHLGRENSKA SJUKHUSET, GOTHENBURG, SWEDEN

MANDIBULAR EROSION IN TUMOURS OF THE MAJOR SALIVARY GLANDS

by

W PAUL BUTT LARS HOLLENDER and INGEMAR STENER

Expansive processes may cause erosion of adjacent bone (e g Lehrbuch der Rontgendiagnostik 1965) but scant attention has been given to this fact in neoplasms of the salivary glands BLADY & HOCKER (1938) in reporting 76 cases of salivary gland tumours stated that "Pressure erosion or atrophy of the mandible either along the posterior or lateral aspects occur in a number of cases in which large tumours have been present for long periods GARUSI (1964) described a fibromyxoepithelioma that had eroded the posterior border of the mandibular ramus

BUTT HOLLENDER & STENER (1968) in a retrospective study of a large number of sialograms observed a number of mandibular erosions Since no frequency figures regarding this condition were found in the literature the aim of the present study was to determine the relative occurrence of mandibular erosions in tumours of the major salivary glands and whether the signs could be of value in the differential diagnosis

Material and Method The total material comprised 706 cases consisting of 279 histologically verified cases of tumour 385 cases of normal or inflammatory

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Table

Data on the 18 cases of roentgenologically demonstrated mandibular erosions in tumours of the major salivary glands

Sex	Age (years)	Gland	Duration of symptoms (years)	Histologic diagnosis
Female	38	Left parotid gland	> 1	Adenocarcinoma
Male	41		14	Benign pleomorphic adenoma
Male	46		> 2	Adenocarcinoma
Female	47		5—6	Semimalignant pleomorphic adenoma
Female	61		> 5	Malignant pleomorphic adenoma
Female	62		7	Benign pleomorphic adenoma
Female	63		6—7	Semimalignant pleomorphic adenoma
Female	72		Recurrent tumour	Benign pleomorphic adenoma
Female	22	Right parotid gland	1	Benign pleomorphic adenoma
Male	28		> 2	Semimalignant pleomorphic adenoma
Female	44		2	Benign pleomorphic adenoma
Male	45		2	Semimalignant pleomorphic adenoma
Male	47		~ 2	Benign pleomorphic adenoma
Female	52		> 1	Benign pleomorphic adenoma
Female	60		~ 1	Semimalignant pleomorphic adenoma
Female	82		> 1	Mucoepidermoid carcinoma
Male	54	Left submandibular gland	4	Adenocarcinoma
Male	61		~ 5	Semimalignant pleomorphic adenoma

conditions, and 42 cases of probable tumour which were not included in the present investigation because the diagnosis had not been confirmed. Histologic verification was obtained in 43 of the inflammatory cases which originally had been considered as cases of tumour and subjected to surgery. Other cases of swellings were considered inflammatory in origin when prompt relief of symptoms was obtained by medical treatment.

At least two of the authors re-examined all the sialograms independently for erosions. The 385 cases which were diagnosed as normal or inflammatory were used as controls. An important part of the re-examination consisted of a comparison between both the mandibular rami in cases of unilateral tumours. There were three cases of bilateral new growths in the total material.



Fig 1 Mandibular erosion in a case of benign pleomorphic adenoma a) Impression in posterior part of mandibular ramus b) Sialogram. The defect corresponds to the expanding tumour

Results

Mandibular erosion occurred in eighteen of the 279 cases of tumour of the salivary glands indicating a frequency of about 6 % these cases are listed in the table on page 236 There was complete agreement between observers in these cases In none of the 385 cases serving as controls could the examiners find any changes in structure and contour of the mandible resembling those present in the tumour cases The sex distribution in the tumour cases with mandibular erosion was similar to the one in the main group of 279 tumours Sixteen of the tumours occurred in the parotid glands and two in the submandibular glands The duration of symptoms as derived from the case histories ranged from 1 to 14 years the mean duration being about 4 years Most of the tumours were large those in the parotid glands were usually located posteriorly

The histologic diagnosis was benign pleomorphic adenoma in 7 cases semimalignant pleomorphic adenoma in 6 and malignant tumours in 5 cases This implies a relatively higher incidence of semimalignant pleomorphic adenomas and malignant tumours than in the total material of 279 neoplasms The erosions except in two cases had well defined smooth borders

A well defined depression in the posterior part of the mandible was seen in several of the benign tumours of the parotid gland (Fig 1) The sharply demar



Fig 2 Defect in lower part of the mandible caused by a semimalignant pleomorphic adenoma



Fig 3 Adenocarcinoma Well defined defect in the lower posterior part of ramus.

cated defect in the lower part of the mandible, demonstrated in Fig 2, was caused by a semimalignant pleomorphic adenoma Malignant tumours produced the defects that are seen in Figs 3, 4 and 5

Discussion

The present material may be considered representative of cases that are subjected to sialography because of the possible presence of tumour The location, size, duration, and type of tumour may be of importance in the occurrence of mandibular erosions Most of the parotid tumours were located posteriorly, implying a close relationship to the posterior part of the mandibular ramus

All tumours were large excepting in the case presented in Fig 3 Roentgenologically demonstrable bone erosion indicates a tumour of long standing, a fact supported by the duration of signs in the present cases The duration is based on the case history and thus subject to great sources of error the figures given should be regarded as minimum values

The relatively higher incidence of semimalignant pleomorphic adenomas and malignant tumours seems to indicate that these are more liable to cause erosion this is in accordance with their way of growth In two of the cases of malignancy, irregular borders of the bone erosion indicated infiltrative growth No definite correlation between type of erosion and type of tumour could however be established The presence of destruction does therefore not allow of a differential diagnosis, e g between benign and malignant growths although poorly demarcated erosion must be highly suggestive of the latter Mandibular destruction on



Fig 4 Malignant pleomorphic adenoma Large punched out defect in ramus and widening of the mandbular notch



Fig 5 Mucoepidermoid carcinoma eroding posterior part of mandibular ramus

the other hand indicates a salivary gland tumour even if it cannot be demonstrated by the sialogram The primary roentgenologic diagnosis in one of the cases for example was that of a normal salivary gland (Fig 3)

Deviation from the normal mandibular contour may, however be produced by other conditions than salivary gland neoplasms Anomalies may result in a change in shape of the mandible and defects following surgery and trauma must also be considered (Fig 3) The case history will generally suggest the cause Tumours arising primarily within the mandible as well as metastases may also produce defects similar to those present in salivary gland tumours Another mandibular defect usually occurring near the mandibular angle is the so-called idiopathic bone cavity that has been reported to contain among other things normal salivary gland tissue (STAFNE 1963) and normal fibrous tissue (BERGENHOLTZ & PERSSON 1963) None of the present erosions resembled an idiopathic bone cavity

It is evident that pathologic conditions other than salivary gland tumours can not be totally excluded from causing mandibular erosions The value of the detection of an erosion is that irrespective of the sialographic findings the probability of a salivary gland tumour must be considered

SUMMARY

Mandibular erosion was evident in 18 cases (6 per cent) of 279 histologically verified salivary gland tumours. Both malignant and benign growths caused erosion. Erosion was not present in a control material of 385 cases of normal or inflamed salivary glands implying that this sign is a strong indication of salivary gland tumour.

ZUSAMMENFASSUNG

In 18 Fällen (6 Prozent) aus einem Gesamtmaterial von 279 Fällen histologisch bestätigter Tumoren der Speicheldrüsen wurde Erosion des Kiefers festgestellt. Erosion war bei bösartigen sowie bei gutartigen Tumoren vorhanden. Bei einem Kontrollmaterial von 385 Fällen von normalen oder entzündlich erkrankten Speicheldrüsen konnte keine Erosion des Kiefers beobachtet werden, was darauf deutet, dass Erosion eine wertvolle Indikation von Tumor der Speicheldrüsen ist.

RÉSUMÉ

Sur 279 tumeurs des glandes salivaires vérifiées histologiquement, il y avait une érosion évidente de la mandibule dans 18 cas (6 pour cent). Ces érosions peuvent être causées aussi bien par des tumeurs bénignes que par des tumeurs malignes. Sur une série témoin de 385 cas de glandes salivaires normales ou infectées il n'y avait pas d'érosion, ce qui implique que ce signe doit faire soupçonner une tumeur de la glande salivaire.

REFERENCES

BERGENHOLTZ, A. and PERSSON, G.: Idiopatiska benkaviteter. Odont. T. 71 (1963), 113.

BLADY, J. V. and HOCKER, A. F.: Sialography: its technique and application in the roentgen study of neoplasms of the parotid gland. Surg. Gynec. Obstet. 67 (1938), 777.

BUTT, W. P., HOLLENDER, L. and STENER, I.: Sialography in tumours of the major salivary glands. To be published in Acta radiol. Diagnosis.

GARUSI, G. F.: The salivary glands in radiological diagnosis. Bibl. radiol. 4 (1964).

LEHRBUCH DER RÖNTGENDIAGNOSTIK. Herausgeg. von H. R. SCHINZ, W. E. BAENSCH, W. FROMMHOLD et coll. Georg Thieme Verlag, Stuttgart 1965.

STAFNE, E. C.: Oral roentgenographic diagnosis. W. B. Saunders, Philadelphia 1963.

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VERTEBRA PLANA DUE TO HISTIOCYTOSIS X SERIAL STUDIES

by

STEPHEN A KIEFFER MARK E NESBIT and G J D ANGIO

Osseous lesions are the hallmark of histiocytosis X since the skeleton represents the most common involved organ system and furthermore usually presents a characteristic radiographic appearance This enables clinicians to identify a disease entity that is often mistaken for an infectious or metabolic disorder In those cases of histiocytosis X without bone lesions the diagnos s is often in doubt and only becomes established when the typical bone lesion occurs

A review of the accumulated clinical experience at the University of Minnesota Hospitals since 1950 comprises some 48 patients with generalized or localized histiocytosis X Lesions were found in the vertebral column in ten patients Characteristic radiographic findings include a variable degree of compression of the vertebral body either symmetrical or asymmetrical preservation of the intervertebral disc and absence of associated soft tissue mass The most severe degree of compression is termed vertebra plana

Serial radiographic studies over periods varying from 6 months to 11 years reveal some restoration of vertebral height in nearly all cases Complete recon

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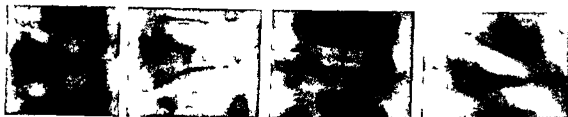


Fig 1 Asymmetric compression of the body of T6 in a 5 year old boy *Left* A p view Almost complete collapse of the left half of the body of T6 the left pedicle is destroyed adjacent disc spaces widened *Right* Follow up film 3 years later Partial restitution of height of left side persistent disc space widening but to a lesser degree than 3 years earlier mild scoliosis

Fig 2 Vertebra plana of T11 in a 6 year old girl The vertebra is compressed into a sclerotic wafer which projects anterior to the margins of adjacent uninvolved vertebral bodies preservation of the pedicles and laminae, less compression of the posterior aspect of the vertebral body due to preservation of the pedicles

stitution, however, was not seen in this group nor has it been documented conclusively by others (FRIPP 1958)

Radiographic findings

A detailed presentation of the clinical aspects of these cases is reported elsewhere (NESBIT et coll) Radiographic studies of all these patients were reviewed by two of the authors (M N and S K) for evidence of vertebral involvement A total of ten patients (six males, four females), all under the age of 15 years, exhibited vertebral involvement at some time during the course of their disease Four of the ten had lesions only in the skeletal system In one of these patients, collapse of the sixth thoracic vertebra represented the patient s only lesion, open biopsy of the vertebral body confirmed the diagnosis of eosinophilic granuloma

In the other six patients having both skeletal and visceral involvement a total of 31 vertebral lesions was found In one patient, followed over a period of seven years, eleven different vertebrae showed radiographic evidence of histiocytosis

Of the total of 35 vertebral lesions three were found in the cervical spine, twenty in the thoracic spine and twelve in the lumbar spine Taking into account the total number of vertebral bodies at risk in these ten patients, the incidence was greatest in the lumbar (12 50) then the thoracic (20 120), and lastly the cervical (3 70)

Most typically, vertebral involvement appeared radiographically as a variable degree of compression of a vertebral body Irregularity may be noted of the superior or inferior plate of the body Immediately beneath this irregularity there is often a sclerotic line likely due to compression of bony trabeculae This ap

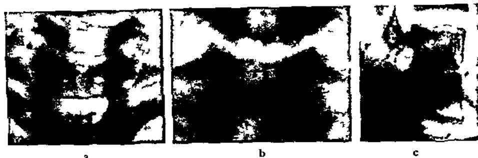


Fig 3 (same patient as in fig 2) Irregular lysis of the superior plate of T1 with slight compression of this vertebra (a) in a 9 year-old girl b) and c) A p and lateral views 3 years later showing very little if any loss in height of the body of T1 however there is now a fusion of the bodies of C7 and T1 with complete loss of the intervening disc space

pearance was noted in twenty eight of the thirty five vertebral lesions Lysis of trabeculae without compression was not seen in any patient even though two children had complaints of pain with negative spine films 2 to 3 months prior to radiographic detection of a compressed vertebra. The degree of compression may be asymmetrical although more often it is symmetrical Involvement of the pedicles is rare in this disease, only one case having been reported in the literature (FAWCITT 1940) However one patient in our series did show destruction of a pedicle (Fig 1)

Six of the lesions in our series were so severely compressed as to be termed a vertebra plana. We have defined this as a complete collapse of the vertebral body with a vertical height of 2 mm or less (Fig 2) In the lateral projection the resulting wafer like vertebra appears sclerotic and elongated so that it projects



Fig 4 Lytic lesion of the posterior spinous process of C2 in a 5 year-old boy a) The cortical margin is broken adjacent to the tip of the arrow b) Follow up study 3 years after detection of the lesion. No residual deformity

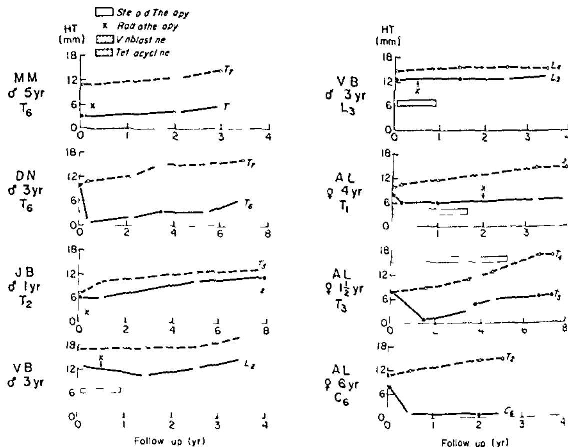


Fig 5 a Histiocytosis involving vertebral bodies serial studies Involved vertebral bodies are measured and recorded in black dots adjacent uninvolved vertebrae are used as controls and recorded as open circles

anterior to the margins of the adjacent uninvolved vertebrae The degree of anterior protrusion was usually slight (less than 3 mm) In one case, the compressed vertebra also projected posteriorly a distance of 2 mm into the spinal canal In all cases, there was less compression of the posterior aspect of the vertebral body likely due to preservation of the pedicles

In almost all cases, the disc space is not narrowed, tending to differentiate this entity from such inflammatory processes as tuberculosis, brucellosis or salmonella infections One exception to this rule was found in our series This was in the child with eleven vertebral lesions She developed an irregular lysis of the superior plate of the first thoracic vertebra in 1964 (Fig 3) Follow up films 3 years later showed the presence of a complete fusion of the bodies of the seventh cervical and first thoracic vertebrae *Although the possibility of a superimposed bacterial* inflammatory process cannot be ruled out, there was no clinical evidence in this

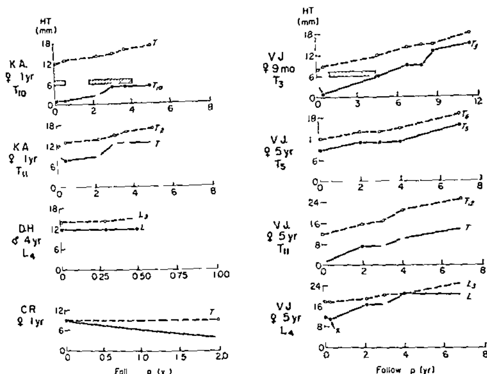


Fig 5 b For legend see Fig 5 a opposite page

patient to support that possibility In the majority of patients with vertebral compression disc spaces adjacent to the compressed vertebrae appeared expanded on the roentgenogram However a portion of the thickness of this space must be occupied by the cartilaginous plate of the compressed vertebral body

Although tuberculosis is frequently mentioned in the early literature as a probable cause of vertebra plana (CALVE 1925) a verified case has not been documented in the literature to this date

Also tending to differentiate histiocytosis X from inflammatory processes involving the vertebral bodies is the lack of any associated paravertebral soft tissue mass No paravertebral soft tissue swelling was detected in any of the thirty five lesions demonstrated in this group

In one patient a small localized lytic lesion of the posterior spinous process of C2 was detected (Fig 4) The lesion was irradiated and radiographic evidence of healing was noted one month after completion of the treatment course Follow up films 3 years after the detection of the lesion showed no residual deformity in a normal appearing spinous process.



Fig 6 Vertebra plana of T11 Follow up films 7 years later of same lesion as in fig 2 Considerable restitution of height persistent anterior and central wedging and minimal anterior protrusion

Serial studies

With respect to follow up of these lesions, eighteen of the thirty five involved vertebrae were well demonstrated on serial studies over periods varying from 6 months to 11 years (Fig 5) Mean follow up time for the entire group is 4 5 years Measurements of vertebral height were made on available roentgen films obtained at intervals during the course of the disease Vertical height was defined as the distance between the superior and inferior ossified margins of the vertebral body under study Measurements of wedged vertebrae were made at the anterior margin

With time the compressed vertebra tends to resume vertical growth Fourteen of the seventeen vertebral body lesions increased in height during the period of observation In seven lesions, as compared with adjacent uninvolved vertebrae, the involved vertebral body showed a greater increase in vertical height measurement over a given period of time This we have called a compensatory spurt The cause of this phenomenon is not understood In one patient with two lesions *the 'spurt occurred shortly after cessation of steroid therapy* This was not seen, however, in three other patients on steroids

The most remarkable improvement in this series was in a vertebra plana of T3 followed for 11 years On the most recent examination, the involved vertebra measured 83 % of the height of the adjacent uninvolved body Five of the six vertebral bodies characterized as vertebra plana showed partial restitution of height over the follow up course which varied from 5 to 11 years Anterior protrusion of a vertebra plana was originally found in four of the six cases After one year, only two of these six lesions displayed anterior protrusion

Some degree of deformity of superior or inferior plates is usually retained during this period of growth The deformity may be minimal in patients follow-

ed over many years Often the actively growing vertebral body gives a bone within bone appearance Scoliosis has been seen in all cases where vertebral compression was asymmetrical In only one patient however was the scoliotic curve greater than 10 degrees This was a child with asymmetric lesions of L2 and L3 who developed an angle of curvature in the thoracolumbar region of 27 degrees A Milwaukee brace has been employed with considerable improvement of the curve

Of the seventeen lesions which involved the vertebral bodies, seven demonstrated a definite spurt in measured height during the regenerative phase as compared with adjacent uninvolved vertebrae Of these seven three had been treated with radiotherapy and four had not a difference which is not significant Of the total group of eighteen lesions involving the vertebral bodies and neural arches eight lesions received external orthovoltage or cobalt irradiation with doses ranging from 450 to 1 600 rad There was no significant difference in growth in height between those lesions which were irradiated and those not receiving radiation therapy

Two of the five children with back pain had negative roentgen films at the onset of the pain Lesions of the vertebral bodies were detected on follow up films at 3 and 6 months respectively

Discussion

In 1924 at the annual meeting of the British Orthopedic Society held in Bologna Italy CALVE (1925) described the radiographic appearance of vertebra plana and suggested that this represented the result of an osteochondritis or aseptic necrosis In subsequent years this entity acquired the eponym of CALVE S disease It was only as recently as 1952 that FAIRBANK suggested that vertebra plana was in most cases a manifestation of histiocytosis X a finding which was verified by the report of four biopsy proven cases by COMPERE et coll in 1954

Although histiocytosis X is the most common histologically proven cause of vertebra plana it is by no means the only verified etiology Gaucher s disease (BURTON 1935) osteogenesis imperfecta, lymphoma (BUCY 1962) and metastatic carcinoma (ALEXANDER 1956) have all been reported to cause vertebra plana

The phenomenon of an apparent compensatory spurt or acceleration of growth in a previously diseased vertebral body is not well understood The process of bony lysis and compression does not appear to involve cartilage, as evidenced by the preservation and actual widening of the intervertebral disc spaces adjacent to the compressed vertebrae A significant portion of this disc space is occupied by the cartilaginous end plates of these vertebrae in young children Since these

cartilaginous end plates are probably not involved by histiocytosis X, the process of calcification and ossification which normally occurs in these end plates and accounts for the vertical growth of the vertebra likely continues despite the compression of adjacent bone and may account for the spurt

This hypothesis, that the increase in height is the result of accelerated ossification in cartilaginous end plates rather than an actual sudden increase in growth rate, is given some credence by (1) the fact that the intervertebral disc space narrows when the spurt takes place, and (2) the growth curves (Fig 5) fail to show a sustained acceleration Indeed, if the curves are drawn between early and late points only, they very closely parallel the growth of the control vertebral bodies We therefore conclude that the spurt is more apparent than real, and that vertebral body growth rate is probably more nearly uniform

Of the ten patients, two were receiving adrenal steroids, one vinblastine and one tetracycline when the diagnosis of vertebral involvement was made None of these medications affected the eventual regeneration of vertebral height as compared with those patients not on chemotherapy (Fig 5)

The *prognosis* with vertebral lesions of histiocytosis X appears very good Independent of the treatment given, some regrowth of the vertebral body occurred in all but three instances Two of these children died from generalized involvement six months and one year after demonstration of the vertebral lesion The third child has been followed a period of 3 years without definite growth

Pain is a frequent early symptom of bony involvement The fact that two of the five children in our series with back pain had negative roentgen films at the onset of pain emphasizes the point that a negative roentgenogram only demands further study and careful observation

In two patients with severe pain localized to the spine, radiation therapy was given immediately and pain was absent two weeks following the conclusion of the treatment One child had spontaneous regression of pain without any treatment in three weeks However, in two other patients with pain there was no remission during observation of 2 weeks and 3 months respectively Once irradiation was given, however, the pain cleared rapidly in both of these patients

We have found that a course of a total of 450 rad, given in 150 rad divided doses over 3 days using orthovoltage apparatus, or a total of 525 rad using cobalt 60 radiation is effective in relieving pain Higher doses do not appear to improve the result The affected vertebral body and the ones immediately above and below are included in the treatment field The width of the field is adjusted so as to include the entire vertebral body Preliminary fluoroscopy is employed to insure accuracy of beam placement, and the treatment is documented on portal films

We cannot detect any significant difference in eventual growth of the involved

vertebrae between those receiving radiotherapy and those not receiving such treatment Thus restitution in height of the vertebral body was neither enhanced nor hampered by irradiation in the doses given Radiotherapy is therefore recommended only for symptomatic lesions and in those cases where there is partial collapse which appears to be progressing despite symptomatic and supportive measures For asymptomatic patients with already completely collapsed vertebrae (vertebra plana) radiotherapy would seem to be unnecessary

SUMMARY

Eosinophilic granuloma as a manifestation of localized or generalized histiocytosis X involved the vertebral column in a group of ten children Characteristic radiographic findings include a variable degree of collapse of the vertebral body either symmetrical or asymmetrical lack of involvement of the intervertebral disc in all but one unusual case and absence of any adjacent paravertebral soft tissue mass Restoration of vertebral height occurred in varying degree Seven lesions appeared to have made a compensatory spurt in height over a given period of time as compared with adjacent uninvolved vertebrae The degree of restoration of vertebral height does not appear to be affected by the type of treatment given

ZUSAMMENFASSUNG

Eosinophile Granulome der Wirbelsäule wurden als Manifestation lokalisierter oder generalisierter Reticuloendotheliose in zehn Kindern beobachtet Charakteristische röntgenologische Erscheinungen inkludierten Kollaps des Wirbelkörpers in variablem Grade symmetrisch oder unsymmetrisch ohne Veränderung der Zwischenwirbelscheibe mit Ausnahme von einem ungewöhnlichen Falle und Abwesenheit von angrenzendem paravertebralen Weichteiltumor Wiederholung der vertebralen Höhe fand in variiertem Masse statt Bei sieben Wirbel Läsionen erscheint es als ob eine kompensatorische Zunahme der Höhe im Vergleich mit naheliegenden unveränderten Vertebrae während einer gegebenen Zeitperiode stattgefunden hatte Die Wiederholung der vertebralen Höhe scheint nicht von der Behandlungsart beeinflusst zu sein

RÉSUMÉ

Les auteurs décrivent chez dix enfants des localisations vertébrales de granulome éosinophile manifestation d une histiocytose X localisée ou généralisée Les signes radiologiques caractéristiques sont une diminution de hauteur du corps vertébral plus ou moins marqué symétrique ou asymétrique sans atteinte du disque sauf dans un cas inhabituel et sans tuméfaction des parties molles paravertébrales adjacentes L évolution spontanée se fait vers la restauration, dans une mesure variable de la hauteur du corps vertébral Dans sept cas les vertèbres atteintes ont eu une poussée de croissance en hauteur compensatrice par comparaison avec les vertèbres intactes Le degré de restauration en hauteur du corps vertébral ne paraît pas dépendre du type de traitement

REFERENCES

ALEXANDER F Metastatic lesion of vertebral column causing cord compression Neurology 6 (1956) 103

BUCY P C Primary epidural spinal lymphosarcoma J Neurosurg 19 (1962), 142

BURTON J D Spinal disease complicating Gaucher s disease in childhood Proc roy Soc Med 28 (1935) 1027

CALVE J Localized affection of the spine suggesting osteochondritis of the vertebral body with the clinical aspects of Pott s disease J Bone Jt Surg 7 (1925) 41

COMPERE E L JOHNSON W E and COVENTRY M B Vertebra plana (Calve s disease) due to eosinophilic granuloma J Bone Jt Surg 36A (1954) 969

FAIRBANK H A T Recent knowledge of affections of the skeleton in children Gt Ormond Str J (1952) p 83

FAWCITT R Osteochondritis vertebralis (Calve s) associated with pathological changes in other bones Brit J Radiol 13 (1940) 172

FRIPP A T Vertebra plana J Bone Jt Surg 40B (1958) 378

NESBIT M E KIEFFER S A and D ANGIO G J Vertebral involvement in histiocytosis X long term follow up of vertebral involvement in ten children To be published

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CONCENTRA

A new overhead unit for roentgenography in the operation theatre

by

E LINDGREN and K J FENZ

Mobile roentgen apparatus is ordinarily used for roentgen examinations in the operation theatre Certain disadvantages such as the relatively limited output obtainable and the usually short FFD are however apparent The relatively low output of the apparatus is of no great handicap in the examination of bones and joints but in almost all other cases a short exposure time is necessary if standard film quality is to be maintained

Many attempts to increase the power of mobile apparatus have been made in Sweden These have resulted in mobile units of such a weight that battery driven electric motors have to be used to move them with resultant reduced manoeuvrability These relatively large units take up much floor area near the operation table where there is always little space to spare and where a high degree of sterility is required

Most mobile apparatus permit of only a relatively short FFD owing to their moderate output and to the fact that the height of the tube column must not be greater than that of the doorways for example The same roentgen apparatus is often used not only in different theatres but also in wards which may cause

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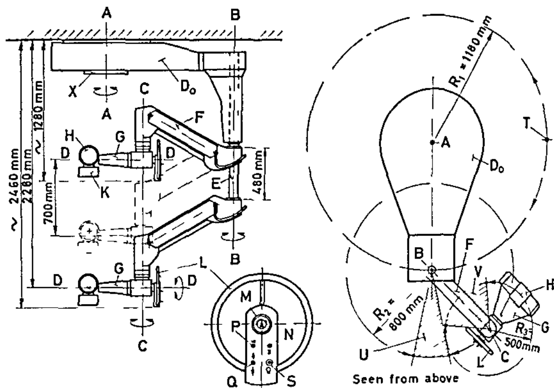
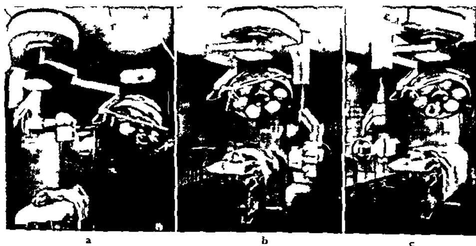


Fig. 1. Schematic drawing of the unit and description of movement. The roentgen tube shield *H* and motor driven light beam diaphragm *K* are mounted on the tube arm *G*. The wheel with control panel *L* enables the tube shield *H* to rotate ± 95° around its horizontal axis *D*. Tube arm *G* and wheel with control panel *L* are attached to the parallelogram arm *F* so that the complete assembly can rotate around the vertical axis *C*. Parallelogram arm *F* attached to the telescopic column *E* has a vertical travel of 700 mm (27.6 inches) which can be combined with the motor driven vertical travel of 480 mm (18.9 inches) of the telescopic column *E*; the total vertical travel of the roentgen tube is therefore 1 180 mm (46.5 inches). Both the parallelogram arm *F* and the tube arm *G* rotate around the vertical axis *B* and in turn the whole assembly coupled to the carriage arm D_0, which is attached to the ceiling, can be rotated around vertical axis *A*.

A — ceiling carriage axis
B — telescopic column axis
C — tube arm vertical axis
D — tube arm horizontal axis
D_0 — carriage arm
E — telescopic column
F — parallelogram arm
G — tube arm
H — roentgen tube shield
K — motor driven light beam diaphragm
L — wheel with control panel
M — beam angle indicator
N P — light beam control switches
Q — control switch for vertical movement of telescopic column
S — switch energizing light beam diaphragm (55 s automatic cut off)
T — adjustable stop pin
U V — area requiring adjustment of carriage arm for radiation coverage
X — mounting plate for operation lamp

cross infection. The high and low voltage cables hanging over or near the operation field introduce sterility hazards, particularly when the radiation beam is vertical. The adjustment of the tube and beam diaphragm above the field is also to be deprecated.



a b c

Fig 9 Concentric installation in an operating theatre Vertical (a) and horizontal beam directions (b c)

An attempt has therefore been made to eliminate all these disadvantages of mobile units by the introduction of a new design principle

The tube is mounted by means of a linked arm system to a symmetrically rotatory carriage which together with the operation lamp is suspended from the ceiling above the operation table Each theatre has its own ceiling tube connected to a central stationary generator with a control panel outside the theatre and remote control for fluoroscopy and exposure of films

If a vertical beam direction is considered sufficient the ceiling suspension may be of simple construction particularly if the focus-to-floor distance can be kept constant This requires a special rather expensive, operation table not only movable in a vertical direction but also equipped with a floating top for exact positioning of the patient this however often impedes the surgical team An optional beam direction requires a slightly more complicated and consequently more expensive construction of the unit which on the other hand may be combined with any operation table and permit any roentgenographic examination to be performed without moving the patient during the centering procedure The theatres will thus from the roentgenologic viewpoint be equivalent so that the programmation of the operations is facilitated

For easy cleaning the surfaces of the equipment are smooth the cables are located inside the suspension arm system and the traditional type of ceiling rails is avoided The positioning of the tube and the adjustment of the diaphragm are made by remote control All these measures are intended to reduce infection

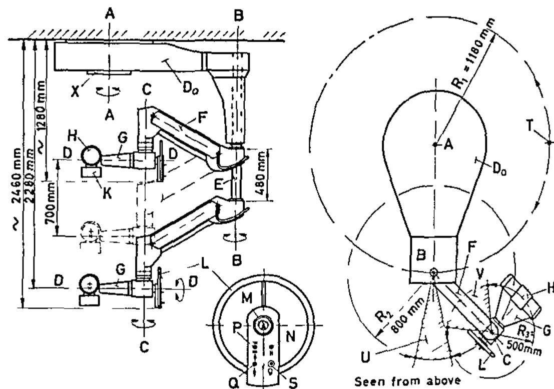


Fig. 1. Schematic drawing of the unit and description of movement. The roentgen tube shield H and motor driven light beam diaphragm K are mounted on the tube arm G. The wheel with control panel L enables the tube shield H to rotate ± 90 around its horizontal axis D. Tube arm G and wheel with control panel L are attached to the parallelogram arm F so that the complete assembly can rotate around the vertical axis C. Parallelogram arm F attached to the telescopic column E has a vertical travel of 700 mm (27.6 inches) which can be combined with the motor driven vertical travel of 480 mm (18.9 inches) of the telescopic column E: the total vertical travel of the roentgen tube is therefore 1 180 mm (46.5 inches). Both the parallelogram arm F and the tube arm G rotate around the vertical axis B and in turn the whole assembly coupled to the carriage arm D which is attached to the ceiling can be rotated around vertical axis A.

A — ceiling carriage axis
B — telescopic column axis
C — tube arm vertical axis
D — tube arm horizontal axis
D_0 — carriage arm
E — telescopic column
F — parallelogram arm
G — tube arm
H — roentgen tube shield
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cross-infection. The high and low-voltage cables hanging over or near the operation field introduce sterility hazards, particularly when the radiation beam is vertical. The adjustment of the tube and beam diaphragm above the field is also to be deprecated.

controls and indicators — motor driven light beam diaphragm motor for the telescopic movement direction finder and angle indicator — are contained in a small control panel mounted centrally Because all high and low tension cables are concealed within the Concentra, all rotational movements must be stopped automatically at a suitable point Movement around axis 1 is stopped by an adjustable pin (*T*) which can be set in the most convenient place Rotations around axis (*B*) and (*C*) are illustrated in the right hand diagram of Fig 1 Angle (*U*) cannot be reached by parallelogram arm (*F*) and angle (*V*) cannot be reached by tube arm (*G*) areas (*U*) and (*V*) can be reached by repositioning carriage arm (*D*) Any point within the radial reach of the Concentra can therefore be covered by the central roentgen ray beam Any operation lamp desired may be fixed to the circular mounting plate V independently rotatory around the same vertical axis *A* as the roentgen unit carriage arm

Comments

Figs 2 and 3 depict the unit installed in a theatre and the different beam directions in Fig 4 the unit is seen when not in use The distance between the lowest point of the unit in this position and the floor will be apparent by comparing the heights of the unit and the doorway The operation lamp can if desired be mounted eccentrically (Fig 3)

Roentgen television is now more and more in use in theatres. The units are mobile and generally based on the *C* arc principle a single tank apparatus at one end of the arc with the image intensifier at the other The generator has a rather low output and the image intensifier usually a diameter of only 6 or 7 inches It is not possible to locate the cables inside the unit The advantages are on the other hand that any direction of beam with constant centering of tube and intensifier is possible If the Concentra unit is mounted in the theatre a separate mobile image intensifier must be used The centering of the tube in relation to the intensifier is not as easy as with a *C* arc unit but after a little practice the difficulty will be overcome and the advantages of a mobile 9 or 10 inch image intensifier may be utilized The mobile image intensifier takes up much less floor space than a *C* arc unit

This new principle would appear to fulfill the requirements for a compact unit assuring a high degree of sterility and saving of floor space Furthermore the tube arm is out of the way of the operation lamp and the tube at no time will restrict the activities of the operating team or the theatre staff

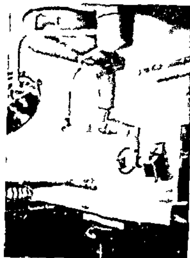



Fig 3 Eccentric installation of unit oblique beam direction

Fig 4 Unit when not in use tube directed along the wall

and thus help in maintaining sterility in the theatre The placement of the *generator-control section outside the main room reduces the risk of anaesthetic* explosion

Constructional details

Fig 1 is a drawing of the new equipment for optional beam direction A ceiling carriage arm *D* is rotatory around its vertical axis *A* A vertical motor driven telescopic column *E* is attached to this carriage arm and at its lower end a manually operated parallelogram arm *F*, counterbalanced by springs, is fixed This arm increases the vertical movement of the roentgen tube that is attached to its other end the parallelogram arm is rotatory around axis *B* of the telescopic column and the tube arm around axis *C* An arm system with linkages R_1, R_2 and R_3 of constant lengths allowing necessary movements of the tube, is thus formed

The area of function of the unit is achieved through separate rotational movements carriage arm (*D*) ($R_1 = 1\,180$ mm = = 46 5 inches) parallelogram arm (*F*) ($R_2 = 800$ mm = 31 5 inches) and tube arm (*G*) ($R_3 =$ = 500 *mm* = 19 7 *inches*)

Oblique or horizontal beam directions may be obtained by manually rotating the tube around axis *D* by means of the wheel *L* (Fig 1), which also controls the whole ceiling suspension system The distance of the wheel (and thus the hands of the operator) from the tube is approximately 800 mm The necessary

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SPINAL CORD TOLERANCE TO ROENTGEN CONTRAST MEDIA PARTICULARLY DURING AORTOGRAPHY WITH TEMPORARY OCCLUSION OF THE AORTA

An experimental investigation in dogs

by

GUNNAR TORNELL

NORDENSTROM (1954) in developing a technique for demonstrating the small vessels arising from the aorta proved in dogs that occlusion of the descending aorta with a balloon and injection of contrast medium above the occlusion was technically possible The main problem was the toxicity of the contrast medium to the spinal cord The present investigation in dogs was undertaken in order to study the spinal cord tolerance to different contrast media under the most unfavourable circumstances i e circulatory arrest The effect of various media, as well as the significance of the concentration of the solutions and the number of injections were all investigated

Earlier investigations

Risks of occlusion of the descending thoracic and abdominal aortae The occlusion procedure itself without contrast injection into the aorta may cause spinal cord damage as was shown as early as in 1667 by STENO CARREL (1910) demonstrated that operative clamping of the descending aorta for 10 to 15 minutes

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SUMMARY

A new unit for radiography in the operation theatre is described. A high degree of sterility is assured, space is saved and the operating staff is unimpeded.

ZUSAMMENFASSUNG

Eine neue Röntgenapparatur für den Operationssaal wird beschrieben. Diese ermöglicht hochgradige Sterilität, nimmt wenig Platz ein und behindert nicht das Operationspersonal.

RÉSUMÉ

Les auteurs décrivent un nouvel appareil pour la radiographie en salle d'opération. Il permet un haut degré de stérilité, prend peu de place et ne gêne pas l'équipe opératoire.

Cardiovascular effects during occlusion of the aorta The blood pressure above the occluded aorta generally increases from 40 to 60 mm Hg and there is a marked decrease of the blood volume in the splanchnic area (BURTON OPITZ 1921, WATKINS 1947 ALLBAUGH et coll 1954) When the aorta had been occluded above the coeliac artery for 10 minutes it was considered that 20 minutes need elapse after the clamp had been released before the circulation became stabilized (BURCH et coll 1953) WATKINS studied the effect of unclamping after occlusion of the descending aorta He found that a sudden release after occlusion *for 5 to 15 minutes could produce an abrupt fall in the arterial pressure* This was caused by blood refilling the splanchnic area that had been emptied during the occlusion One dog of ten died after a sudden release

Decreased frequency of spinal cord damage was reported by GOBBEL JR et coll (1958) when the inferior vena cava was occluded simultaneously with occlusion of the thoracic aorta

Toxic effects of contrast media during aortography without occlusion Damage to the spinal cord caused by contrast media has been experimentally investigated by HOL & SKJERVEN (1954) who found that iodopyracet 70 % in rabbits produced damage to the spinal cord of the same type as demonstrated in the brains of rabbits by BROMAN & OLSSON (1948) Repeat injections and a supine position of the animal increased the damage to the spinal cord

MARGOLIS et coll made physiologic neurologic and pathologic examinations of the spinal cord of dogs after aortography as reported in a number of papers during 1956—1966 They regarded the spinal cord of dogs as ideal for testing the toxic effect of different contrast media. They described pathologic changes in *the spinal cord damage to the blood brain barrier* circulatory disturbances and clumping of red cells in the cord vessels They also demonstrated a protecting effect of procaine 2 % glucose 20 % and vasodepressor agents *given some* minutes before the injection of sodium acetrizoate 70 % They believed that the vasodepressor agent caused a shunt of the intra aortically administered injection mass towards the periphery and away from the cord

The doses of different contrast media that were tolerated without neurologic *impairment but sometimes caused anatomic lesions* after aortography at the level of L 3 in 79 dogs were found to be

	Per cent	ml/kg bodyweight
Diodrast	70	1
Urokon	40	1
Miokon (diprotrizoate)	,0	1
Hypaque	0	3
Renografin	0	3

For synonyms of contrast media see Table 1

or more gave the dog spastic paresis of the hind legs The damage was explained by the probable hypoxemia of the spinal cord below the occlusion The changes were localized to the anterior horn Many experiments have been made to find out for how long the aorta can be occluded without risk to the spinal cord ALLBAUGH et coll (1954) occluded the aorta at the level of Th 4—5 for 20 minutes, one out of nine dogs died and one developed transient paresis of the hind legs PARKINS (1955) occluded the aorta with a balloon catheter at the level of Th 8—10 for 30 minutes Two out of ten dogs died and four became paralysed EDWARDS et coll (1954) occluded the descending aorta at the level of Th 13 with a balloon catheter for 30 minutes in ten dogs without adverse effects BURCH et coll (1954), in a material of 114 dogs, reported that the maximal time for occlusion of the aorta was 20 minutes above the coeliac artery, 60 minutes above the superior mesenteric artery, as well as above the renal arteries, and 3 hours above the inferior mesenteric artery GILSEFFI et coll (1957), in 74 experiments in dogs, observed that occlusion above the coeliac artery was possible for 30 minutes, above the superior mesenteric artery for 1 hour, above the renal artery for 2 hours, and below the renal arteries for 4 hours A large number of experiments have also been made in hypothermia, under such circumstances the aorta may be occluded for longer periods

BLAISDELL et coll (1962) occluded the aorta and demonstrated that if the spinal fluid pressure rose to the same level as in the aorta distal to the occlusion, paraplegia more often occurred They considered the probable cause to be that the minimal arterial flow to the spinal cord could not be maintained

Risks of occlusion of the hepatic artery The hepatic artery was temporarily occluded by RAFFUCCI et coll (1951) in three dogs for 1 hour, no damage to the liver was observed By simultaneous occlusion of the hepatic artery, superior mesenteric artery and portal vein, the maximal tolerance time became 20 minutes, longer occlusion caused necrosis of the liver

Risks of occlusion of the renal arteries MOYER et coll (1957) occluded the aorta above the renal arteries for 3 hours without damage Occlusion of one renal artery for 2 hours produced no damage in some cases but in others damage occurred after an hour If the aorta distal to the renal arteries is clamped for 2 hours, damage to the renal tubules has been observed to occur (NANSON 1959)

Thus, *during occlusion of the descending aorta* the spinal cord seems to be the most sensitive tissue, and it will be damaged probably due to hypoxemia if the occlusion lasts for more than 10 to 20 minutes Occlusion of the abdominal aorta for more than 20 to 30 minutes may also cause serious changes in the function of other organs, particularly the liver and the kidneys

Damage to the liver, pancreas and intestine caused by contrast media has rarely been described after moderate doses injected into the coeliac or one mesenteric artery at selective catheterization Simultaneous injection of 0 6 ml/kg Urografin 76 % into the coeliac and the superior mesenteric arteries has been employed as a routine clinical procedure (BOIJSEN et coll 1964, LUNDERQUIST 1965 MIKAELSSON 1965) GRAYSON et coll (1961) dissected out a branch of the mesenteric artery to the small intestine in dogs, inserted a cannula and injected 2 to 16 ml sodium diprotrizoate (Miokon) 50 % Hypaque 50 % and Renografin 60 % Necrosis occurred in the intestine in 58 5 % of the Miokon cases and in 11 8 % of the Hypaque cases but in none of the Renografin cases The same group (FUJII 1963) later reported a comparison between these three media and sodium iothalamate (Angio-Conray) and methylglucamine iothalamate (Conray) with the same content of iodine as in Hypaque 50 % or 25 % The two methyl glucamine salts i e Renografin and Conray were the least toxic COOLEY (1964) also found Renografin 76 % less toxic to the intestine than Hypaque Miokon or Urokon Renografin 76 % 2 to 7 ml/kg injected into the superior mesenteric artery in dogs failed to affect the exposed intestine in 17 of 18 cases

Damage to the kidneys by contrast media has been described in a large number of examinations All modern investigations have confirmed that the diatrizoate and iothalamate types of media are less toxic than those of the acetrizoate iodopyracet or diprotrizoate variety (BERG et coll 1958 HUGER et coll 1958 HELANDER 1958 LINDGREN 1961 MORRIS et coll 1961 KILLEN et coll 1963 RHEA et coll 1964)

Aortography proximal to an occlusion of the aorta Above an occlusion of the descending thoracic aorta the risk of spinal cord injury is considerably increased compared to aortography with the same doses during free circulation because both the total amount and the concentration of the medium reaching the vessels in the cord are higher HENLINE et coll (1936) compressed the abdomen of dogs in order to occlude the abdominal aorta and one dog had convulsions during aortography with 10 ml NaI 100 % NORDENSTROM (1954) occluded the descending aorta in dogs with a balloon catheter and observed hind leg paresis after repeat injections of 1 ml/kg Umbradil 70 % above the occlusion in three out of four dogs

HUGER et coll (1958) occluded the abdominal aorta in dogs with two balloons above and below the renal arteries The injection of 1 ml/kg Urokon between the two balloons produced damage to both the spinal cord and kidneys KILLEN et coll (1959) occluded the abdominal aorta above and below "lumbar artery No 1 in dogs, in order to obtain selective injection into this important artery to the spinal cord With only 2 ml of Urokon 70 % one dog developed para

Table 1

Synonyms of contrast media

Iodopyracet	*Acetrizoates*	*Diatrizoates*	*Metrizoates*	*Iothalamates*
	Sodium salt	Sodium salt	Sodium salt	Sodium salt
49.8 % iodine	65.8 % iodine	59.9 % iodine	58.6 % iodine	59.9 % iodine
Diodon Diodrast Kardiotrast Umbradil	Acétiodone Diaginol Rheopak Triotrast Triurol Urokon	Hypaque < 50 % Mixtures of sodium and methylglucamine salts Hypaque > 50 % Radioselectane urin et vasc Renografin Renovist Urografin	Isopaque Ronpacon Triosil	Angio Conray Conray 400
Methylglucamine salt	Methylglucamine salt	Methylglucamine salt	Methylglucamine salt	Methylglucamine salt
42.3 % iodine	50.7 % iodine	47.1 % iodine	46.8 % iodine	47.1 % iodine
Perabrodil M	Fortombrine M Vasurix	Cardiografin	Isopaque cerebral	Conray

Flom et coll. (1957) performed aortography via the ascending aorta in 50 experiments and stated that the contrast media were 'more neurotoxic than cardiotoxic'. They found that the maximal doses not producing neurologic impairment were somewhat higher than the above mentioned doses.

Killen et coll. (papers published during 1959—1966) graded different contrast media according to their damaging effect on the spinal cord and kidneys. Most toxic was sodium iodine 54.6 %, followed by Urokon 70 %, Neo-iopax 75 %, Miokon 90 %, Diodrast 70 % and Hypaque 90 %. The least toxic was Thorotrast 25 %. They also confirmed the finding that repeated injection at 15 min intervals increased the risk of toxic damage both to the spinal cord and to the kidneys (Killen et coll. 1960). A new medium, sodium iothalamate (Angio Conray) 80 % was regarded by Rhea et coll. (1964) to be less toxic in single injections but when repeated more toxic than the Na methylglucamine diatrizoate (Hypaque 90 %). Stewart et coll. (1965) reported that Angio Conray 80 % carried a significantly high risk of spinal cord damage and recommended a moderate total dose, avoiding of multiple injections, raising of the pH value, and using methylglucamine instead of sodium salt.

sodium intravenously In order to prevent coagulation heparin 100 to 150 IE/kg bodyweight were injected through the catheter A double lumen plastic catheter (Rusch) was used The wide channel of the catheter was utilized for the injection the other narrower channel serving for filling the small balloon at the tip of the catheter The larger channel ended about 1 cm proximal to the balloon For occlusion of the aorta and at the same time for rendering it visible, the balloon was filled with contrast medium

The following media were investigated

	Per cent	Number of dogs
Iod pyracet (Umbradil)	70 or 50	27
Sodium acetrizoate (Rheopak Triurol Urokon)	70 or 50	10
Sodium methylglucamine diatrizoate (Urografin)	76	18
Sodium metrizoate (Isopaque)	60	2
Sodium iothalamate (diluted Angio-Conray)	60	3
NaCl	7 45	1

Of the diatrizoate preparations only Urografin was used in this investigation As seen from Table 1 Urografin is a mixture of the sodium and methylglucamine salts of diatrizoate Sodium diatrizoate is available only up to 50 % With higher concentrations as used in aortographies mixtures with methylglucamine are necessary

NaCl in place of contrast medium was injected in one dog The concentration of the saline solution was 7 45 % or the same concentration of sodium as in sodium iothalamate (Angio-Conray) 80 %

The films were obtained with a single plane film changer except in the cases of the diatrizoate series which were examined with a two-plane roll film changer type Gidlund Elema One film per second was exposed during 10 seconds and 1 ml kg contrast medium was given with each injection except in two experiments The injection equipment consisted of a pressure syringe manipulated by hand (JONSSON et coll 1951) or a pressure syringe (GIDLUND 1956) with which 4 kg pressure was obtained The injection time was 1 to 3 seconds

In five experiments the blood pressure above the occlusion was registered from a cannulated brachial artery connected to an ordinary Hg manometer and a kymograph

Technique of temporary occlusion of the aorta combined with aortography The technique was mainly the same as that described by NORDENSTROM (1954) The catheter was introduced in one of the common carotid arteries and directed during fluoroscopy into the descending thoracic aorta The aorta was occluded

plegia, but 30 ml Hypaque 90 % could be injected without other signs than an increase in the reflexes. SCATLIFF et coll. (1962) used occlusion with a balloon of the abdominal aorta for selective angiography of the coeliac artery. They preferred selective catheterization to balloon occlusion and did not discuss the side effects of the medium injected; they used 10 ml Hypaque 50 % above and below the occlusion.

The method of occluding the aorta during aortography in man was discussed by NORDENSTRÖM & TORNELL (1966).

Conclusions from earlier investigations. A survey of the literature seems to confirm that the main problem involved in aortography above an occluded descending aorta is the high risk of injury to the spinal cord. The occlusion itself seems to be permissible for about 10 minutes. Studies of the toxic effects of contrast media on the cord of dogs have usually been made with injection during normal circulation into the descending thoracic or abdominal aorta. The investigations have demonstrated that the various media have very different toxic effects. Most investigators have found media of the diatrizoate type to be the least toxic. The most toxic medium was generally sodium acetrizoate. Diprotrizoate and iodopyracet were intermediate in effect. Sodium metrizoate and sodium iothalamate were reported to have about as low toxicity as the diatrizoate compounds, when used in the same iodine concentrations. Next to the spinal cord the renal tissue seems to be the most vulnerable.

As regards signs of spinal cord damage, the smallest toxic doses appear to cause only hyperreflexia, which is often difficult to register and evaluate in dogs. Histologic examination of the spinal cord may however reveal changes. If the doses are increased, the animals may develop slight reversible to severe irreversible pareses of the hind legs or even complete paralysis of the hind legs and bladder. Such signs are readily observed and have been useful for measuring and comparing the toxic effects of different solutions of contrast media, as well as the methods of administration. If the aorta is occluded and the medium injected above or below the occlusion, the risk of spinal cord lesions is markedly increased.

Present investigation

Material and Equipment. Sixty one experiments were performed with occlusion of the descending aorta or the abdominal aorta, in dogs weighing between 9 and 30 kg. Anesthesia with pentobarbital sodium 6 %, usually in a dose of 0.5 ml per kg bodyweight intraperitoneally, was given. If necessary, the anesthesia was continued either with open ether or with a supplementary dose of pentobarbital



Fig 2 Recording of blood pressure in the brachial artery during occlusion of the descending aorta, and subsequent injection of contrast medium at the level of Th 9 in a dog Occlusion started (a) injection of 12 5 ml of the contrast medium (b) and occlusion removed (c)

Results

Observations on blood pressure during occlusion of the descending aorta The arterial blood pressure was recorded in 5 dogs A typical experiment is illustrated in Fig 1 After the descending thoracic aorta was occluded, the blood pressure above the occlusion increased from about 130 to about 180 mm Hg with a simultaneous increase in the pressure amplitude The initial increase in blood pressure was followed by a slight reduction When the occlusion was removed after 40 and 75 seconds respectively the blood pressure decreased initially to 50 and 40 mm Hg respectively and then gradually increased to about 100 mm Hg after 30 seconds

In another experiment the blood pressure changes in connection with the injection of the contrast medium were recorded (Fig 2) The blood pressure increased during occlusion at the level of Th 9 The injection was concluded in 2 to 3 seconds The occlusion which lasted for 35 to 40 seconds, was released after the injection The blood pressure then decreased to about 65 In this case the pressure amplitude after release of the occlusion increased The blood pressure gradually returned to its original level which was reached after some minutes

Incidents of spinal cord damage after contrast medium injection above an occluded aorta In the first series of 24 dogs, which were examined in the lateral position the contrast medium was injected once above the occluded aorta as recorded in Table 2 When the supine position was used during the investigation paresis occurred even after sodium acetrizoate 50 % as seen from Table 3 in which the results with the 37 dogs examined supine are given The details of all the paretic cases are given in Table 4 Some of these cases had total paralysis with bladder and rectum paresis which was irreversible for six days after which time the dogs were sacrificed The spinal cord was removed in three dogs Necrotic changes were present both in the gray (particularly in the anterior horn)

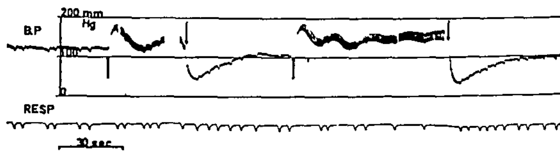


Fig 1 Recording of blood pressure (in the brachial artery) and respiration during occlusion of the descending aorta in a dog Occlusion started ↑ and was released ↓

by filling the balloon with contrast medium until its form was compressed from side to side and its length became about double its width in the aorta The channel of the catheter connected to the balloon was closed, and the catheter was fixed be means of adhesive tape and an arterial clamp to the skin of the neck close to the incision in order to prevent the catheter from being pulled caudally by the blood stream This fixation was sufficient The occlusion for test purposes lasted for about 0 5 to 1 minute, and the occlusion in connection with the contrast medium injection above the balloon never more than 3 minutes Most of the occlusions were made either at the level of Th 8 to 13, or at the level of L 1 immediately distal to the coeliac artery The coeliac artery was easily visible at fluoroscopy in the lateral position when the balloon was filled with contrast medium The bulge of the balloon into the coeliac and the superior mesenteric arteries could readily be observed when it was at the level of these arteries Some test occlusions were first made under fluoroscopic control and the amount of fluid required in the balloon for effective occlusion was determined The balloon was then filled with this amount and fastened, and the contrast medium was injected above it As soon as possible after the exposures, the balloon was emptied

The position of the animal is of importance (HOL et coll 1954) When the contrast medium is injected above an occluded aorta, or into a slow flowing blood stream, or also, though to a lesser degree, when injected into a free circulation, the concentration of the contrast medium increases in the lowest part of the aorta due to layering of the medium When the dog is supine the dorsal vessels receive the largest amount of the medium, and thus the risk of spinal cord damage becomes higher For a study of the amount of medium that may be injected into the aorta, under the most unfavourable conditions, without any untoward effects it is therefore important to make the injection in the supine position In the present material, 37 of the dogs were examined in this position (cf Tables 3 and 4)

Table 3

Frequency of spinal cord damage in dogs in supine position with injections into the aorta above an occluding balloon

No of dogs	Weight kg	Upper margin of ballon at	Contrast medium 1 ml/kg bodyweight	Concentration	Iodine g/ml	Number of injections into the aorta: Ascending aorta: During free circulation	Ascending aorta: During retarded circulation	Above occlusion of the descending aorta	Paresis
10	9—19.5	Th 13—L 3	Iodopyracet	50	0.25	—	—	1	0/10
3	11—16	Th 13—L 2	Sodium acetrizoate (Urokon)	50	0.33	—	—	1	1/3
15	12—29.5	Th 4—L 1	Sodium and methyl glucamine diatrizoate (Urografin)	76	0.37	—	1	1	0/15
2	20+28	Th 8+Th 10	Sodium and methyl glucamine diatrizoate (Urografin)	76	0.37	1	1	1	1/2
1	13	Th 7	Sodium and methyl glucamine diatrizoate (Urografin)	76	0.37	—	—	2	1/1
2	19+24	Th 6+Th 8	Sodium metrizoate (Isopaque)	60	0.35	—	—	2	1/2
3	18—21	Th 8—Th 10	Sodium iothalamate (Angio-Conray)	60	0.36	—	—	2	0/3
1	21	Th 10	NaCl	7.45	—	—	—	2	1/1

developed flaccid paresis not only in the hind legs but also in the fore legs and the dog could only just move its head. In spite of the fact that the first two injections into the ascending aorta were given with the dog lying prone and 45° oblique marked contrast filling of the dorsal branches of the thoracic aorta occurred (Fig. 3 a). The third injection above the occluded aorta at the level of Th 8—9 revealed excessive filling of the dorsal branches above the occlusion (Fig. 3 b).

Table 2

Injections of contrast media above the occluded descending aorta in the first series of 24 dogs

Number of dogs	Contrast medium	Upper margin of balloon occlusion	Injected volume	Iodine g/ml	Paresis
8	Iodopyracet 70 %	Th 7—L 1	1 ml/kg	0.35	3/8
9	Iodopyracet 50 %	Th 5—Th 10	1 ml/kg	0.25	0/9
1	Sodium acetrizoate 70 %	Th 13	1 ml/kg	0.46	1/1
2	Sodium acetrizoate 50 %	Th 7—Th 12	1.5 ml/kg	0.33	1/2
4	Sodium acetrizoate 50 %	Th 5—L 1	1 ml/kg	0.33	0/4

and in the white matter of the spinal cord. The changes were similar to those described by MARGOLIS et coll. (1956). All the dogs that developed paresis after sodium acetrizoate had severe spasm of the hind legs in connection with the injections. No higher degree of contrast filling of the dorsal branches was observed in the paretic group of dogs as compared to the non-paretic one.

Iodopyracet 50 % was tolerated in a dose of 1 ml/kg bodyweight if injected with the dog supine. None of the 10 dogs used in this experiment developed any neurologic signs when observed for 2 to 4 weeks, the iodine content of this compound is only 0.25 g/ml.

When sodium diatrizoate (Urografin) was tested, a repeat injection was first tried. One dog was given 1 ml/kg bodyweight Urografin 76 %. After release of the occlusion at the level of Th 8—9, and an interval of 30 minutes, a further occlusion and injection of the same amount of contrast medium was made. The dog developed complete flaccid paraplegia of the hind legs and paresis of the bladder but had no spasms: the paraplegia was irreversible during four days, after which the dog was sacrificed.

As two injections above the occluded descending aorta were not tolerated, the mode of administration was changed. Thus, in two dogs with normal circulations one injection of 1 ml/kg Urografin 76 % was made into the ascending aorta. Thirty minutes later the same amount was injected into the same part of the aorta, but the blood flow in the aorta was now retarded due to a decrease in cardiac output. This was performed in three different ways: (1) acethylcholine arrest of the heart, (2) increase of the intrabronchial pressure, or (3) occlusion of the inferior vena cava. As the dogs lay prone and in the left oblique position during this angiography under flow retardation, the medium was not directed especially to the dorsal spinal arteries. Thirty minutes later a third injection of the same amount of Urografin 76 % was given, but now into the descending aorta above an occluding balloon with the dog supine. Of these two dogs one

Table 4 *(cont)*

Contrast medium in the dorsal branches	Contrast medium below the occlusion	Number of injections: Into ascending aorta	Number of injections: Above occluded descending aorta	Spasm	Bladder paresis total paresis of hind legs
++++	—	—	1	—	+
++	++	—	1	—	+
++	+++	—	1	—	Died + Histol
+++	—	—	1	+	+
++	(+)	—	1	+	+
+++	—	—	1	+	+
+++	—	—	2	—	+
++++	—	2	1	—	+ and front legs
+++	?	—	2	—	+ not complete some improvement during 3 days
		—	2	—	+ not complete some improvement during 6 days

One dog died four days after angiography due to an epidemic disease The remaining fourteen dogs survived and were completely free from signs during an observation period of 1 to 12 months

Sodium metrizoate and sodium iothalamate were tested in only few experiments The media were both administered in two injections given with a 30-min interval above the temporarily occluded descending aorta The volume was the same and the concentration of iodine almost the same as in a case in which diatrizoate was injected twice and in which paralysis developed

Sodium metrizoate (Isopaque) 60 % was injected in two dogs. One of these developed bladder paralysis and severe but incomplete paresis of the hind legs

Table 4

Dogs with spinal cord damage after injections above the occluded descending aorta

Weight kg	Position	Upper margin of balloon	Lower margin of balloon	Contrast medium	Concentration %	Volume ml/kg per injection	Iodine g/ml
15	Lateral	Th 8	Th 9	Iodopyracet	70	1	0 35
12 5	Lateral	Th 9	Th 10	Iodopyracet	70	1	0 35
12 5	Lateral	Th 8	Th 9	Iodopyracet	70	1	0 35
13 5	Lateral	Th 13	L 1	Sodium acetrizoate	70	1	0 46
17	Lateral	L 2	L 3	Sodium acetrizoate	50	1 5	0 33
16	Supine	Th 13	L 1	Sodium acetrizoate	50	1	0 33
13	Supine	Th 7	Th 8—9	Sodium and methyl glucamine diatrizoate (Urografin)	76	1	0 37
20	Supine	Th 8—9	Th 11	Sodium and methyl glucamine diatrizoate (Urografin)	76	1	0 37
24	Supine	Th 8		Sodium metrizoate	60	1	0 35
21	Supine	Th 10	Th 11	NaCl	7 45	1	0

The other dog staggered a little when walking the day after the examination but two days later there were no neurologic or other signs

As one injection above an occluded descending aorta could cause severe injury to the spinal cord if preceded by two injections into the ascending aorta, new experiments were performed and the number of injections was diminished (Table 3) Only two injections were given First, 1 ml/kg Urografin was injected into the *ascending aorta with the blood flow retarded* Thirty *minutes* later the position of the dog was changed to supine The descending aorta was occluded, and a second injection of 1 ml/kg of the same medium was now made above the occlusion Table 3 indicates that none of the 15 dogs had any neurologic signs

bladder and rectum There was improvement of the hind leg paresis six days later and the dog was able to stand on its legs (Fig 4) The dog was sacrificed on the sixth day and histologic examination (Fig 5) of the spinal cord demonstrated changes of the same type as occurred after injection of contrast media The changes were however not so marked as in the dogs with completely irreversible paresis and were scattered in the white matter with an irregular distribution in the transection demyelination of varying extent and presence of macrophages Immediately above the occlusion and at the level of Th 8 necrobiotic changes total myelin sheath degeneration and lipoid macrophages were present There were no signs of inflammatory changes (pathologist H Nordenstam)

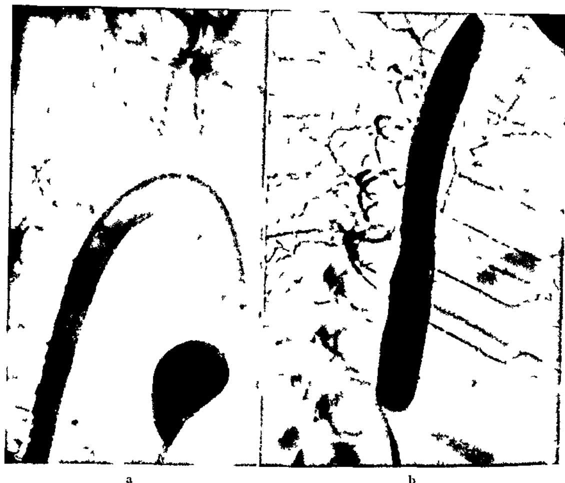
Discussion

Temporary occlusion of the descending thoracic aorta Earlier investigations have indicated that occlusion of the descending thoracic aorta is permissible for about ten minutes and occlusion of the abdominal aorta for 20 to 30 minutes Occlusions did not last longer than 3 minutes in the present investigation this time period allowed for the occlusion procedure injection of the contrast medium exposure of the films and emptying of the occluding balloon The problem of obtaining safe aortographies above the occluded aorta is not the occlusion itself which plays a minor role but the toxicity of the contrast medium Doses that are well tolerated with a free circulation in the aorta become toxic and may produce irreversible paresis when injected into the occluded aorta The doses should be limited to one injection of 1 ml/kg of a contrast medium with a toxicity as low as the media of sodium diatrizoate metrizoate or iothalamate and a concentration of less than 0 37 g iodine/ml The use of methylglucamine salts and the addition of calcium ions are probably to be preferred

The broncho-mediastinal vessels seem to be of particular diagnostic interest in many pulmonary and mediastinal diseases All of them may occasionally be selectively catheterized in man (NORDENSTROM 1963 1965 1967 VIAMONTE 1964 BOIJSEN et coll 1965) but it should be possible by aortography above an occluded descending aorta to demonstrate all the bronchial arteries on both sides

In Fig 6 the bronchial arteries are demonstrated in a dog The aorta was occluded at the level of Th 8 One ml/kg contrast medium was injected *proximal to the occlusion* the bronchial arteries were easily recognized as fairly narrow tortuous vessels However most of the medium injected disappeared through the intercostal arteries and from these it passed into the dorsal ramifications to the spinal cord and musculature of the back

It has sometimes been observed that some of the contrast medium passed the occluding balloon to the aorta distal to the occlusion This may be explained by



a b

Fig 3 Aortograms in a dog receiving three injections of contrast medium each in an amount of 1 ml/kg (The first injection was made into the ascending aorta during free circulation) a) The second injection was made into the descending aorta during retarded circulation with occlusion of the inferior vena cava b) The third injection was made into the descending aorta above an occluding balloon Excessive amount of contrast medium in the dorsal vessels

It improved after five days and was able to walk with difficulty, it was then sacrificed Sodium iothalamate (diluted Angio Conray) 60 % was tested in the same way in three dogs, no neurologic impairment occurred More data from the paralytic cases are given in Table 4

Hypertonic sodium chloride (7 45 %) *was injected above the occluded* abdominal aorta in one dog The solution was administered in the same way as sodium metrizoate and sodium iothalamate, with the dog supine Following temporary occlusion at the level of Th 10, one injection of 1 ml/kg and a second injection after 30 minutes were made No convulsions occurred but after regaining consciousness the dog had flaccid paralysis of the hind legs as well as paresis of the

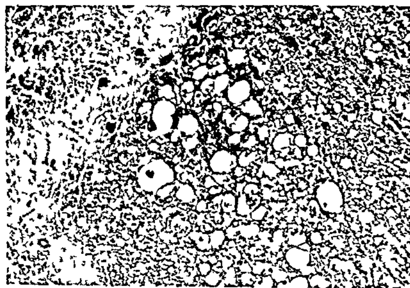


Fig 5 Spinal cord changes c used by hypertonic saline at the level of Th 8 in a dog (the same dog as in fig 4) Myelin sheath degenerat on in the white matter immediately dorsal to the gray commissure

lamate would therefore be difficult but it appears there is justification for concluding that both have a low spinal cord toxicity

The iodine per volume content of the medium is of more interest to the radiologist than the concentration of the chemical compound The iodine content of sodium acetrizoate Urokon) 70 % is 0 46 g ml of sodium methylglucamine diatrizoate (Hypaque M) 90 % 0 46 g ml and of sodium iothalamate (Angio-Conray) 80 % 0 48 g ml The e media may therefore be compared in the concentration obtained from the manufacturers as has been done by KILIEN et coll The iodine content of the media te ted in most of the experiments in the present investigation have been lower and as regards four of the media almost equal sodium acetrizoate (Urokon) 50 %=0 33 g ml sodium methylglucamine diatrizoate (Urografin) 76 % =0 37 g ml sodium iothalamate (Angio-Conray) diluted to 60 %=0 36 g ml and sodium metrizoate (Isopaque) 60 %=0 35 g ml

Until now the discussion has mostly dealt with contrast media with the same anion but the toxicity may of course vary with different cations Many reports have shown that the methylglucamine salts are less toxic than the sodium salts though the latter have the advantage of being less viscous. VOSSE (1960) using the Broman & Olsson method found methylglucamine diatrizoate salts less toxic

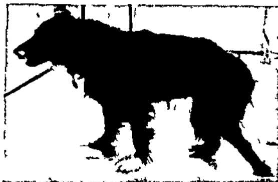


Fig 4 Pareses of the hind legs of a dog after two injections of hypertonic saline (7 45 % NaCl) above the occluded descending aorta at the level of Th 10

a flow through collaterals, but there sometimes seems to be a leakage between the balloon and the aortic wall In the case illustrated in Fig 7, the medium passed the occlusion and, as the flow in the aorta was almost discontinued, the hepatic artery became well filled

Temporary occlusion of the abdominal aorta Most of the large abdominal arteries are readily examined at aortography during free circulation The introduction of selective angiography has improved the diagnostic possibilities of demonstrating changes in the coeliac, mesenteric and renal arteries The need for injection of contrast medium above a temporary occlusion of the abdominal aorta has thus diminished but may be considered when (1) several vessels supply an organ, for instance the adrenals or even the pancreas, when all the supply arteries were not successfully catheterized, (2) when small vessels cannot be easily catheterized selectively, for instance the inferior phrenic or ovarian arteries, or an anomalous artery to a so-called sequestrated lung

Spinal cord tolerance to contrast media The order of toxicity of the various contrast media, reported by most of the earlier investigators referred to in the introduction, has been confirmed by this investigation The most toxic medium is sodium acetrizoate and the least toxic a mixture of the sodium and methyl glucamine diatrizoate salts According to RHEA et coll (1964), sodium iothalamate is less toxic to the spinal cord than sodium diatrizoate in single doses but more toxic in repeated doses In the investigations by KILLEN et coll and RHEA et coll the amount of medium was always 15 ml, and not related to the weight of the animals, which varied from 7 to 16 kg Maybe this fact was the cause of their sometimes contradictory results Only three experiments were performed in the present examination with repeat injections of sodium iothalamate (Conray) 60 % A definite comparison between sodium diatrizoate and sodium iotha



Fig 7 Occlusion of the descending aorta in a dog at the l vel of Th 8—9 Leakage of contrast medium distal to the balloon Marked fill ng of the coeliac artery and its branches

occluded descending aorta may cause paresis Each injection consisted of 1 ml/kg bodyweight at an interval between the two injections of 30 minutes during these injections the occlusion of the aorta lasted less than 1 5 minutes In one case parc is also occurred when one injection above the occluded aorta was made but this injection was preceded by two injections into the ascending aorta without occlusion All these three injections also consi ted of 1 ml/kg diatrizoate (Urografin) 76 % with intervals between each of the three injections of about 30 minutes

The pathologic findings were of the same type as the grade III and IV described by MARGOLIS et coll (1959) in the cases in which the spinal cord was examined microscopically These authors demonstrated a correlation between the neurologic impairment and the anatomic lesion although not between any convulsive effect and injury to the spinal cord The lesions consisted in sparsely scat



Fig 6 Bronchial arteries filled in a dog after injection of contrast medium above the occluded descending aorta at the level of Th 8

to the bloodbrain barrier STEWART et coll (1965) reported the same concerning iothalamate SALVESEN et coll (1967), GONSETTE et coll (1967), OLIN et coll (1967) stated that the toxicity of sodium metrizoate on the blood brain barrier was reduced by the addition of small amounts of calcium ions

The concentration of the medium is of great importance in the production of damage to the spinal cord Iodopyracet 70 % was not tolerated but iodopyracet 50 % could be given in a dose of 1 ml/kg The higher concentrations have a disproportionately greater effect than the lower ones as regards the vasodilating effect (LINDGREN et coll 1958, and LINDGREN, SALTZMAN & TORNELL (1968) and, according to TINDALL et coll (1958), and FOSTER et coll (1964) also on the damaging effect to the spinal cord

Repeat injections of contrast media increase the risk of damage to the brain, as demonstrated by BROMAN & OLSSON (1949), and to the spinal cord (HOL et coll 1954, KILLEN et coll 1960, STEWART et coll 1965) The most remarkable finding of the present investigation was that one of the least toxic of the media sodium methylglucamine diatrizoate (Urografin) 76 % injected twice into the

nad) and other substances (PINET et coll 1959), as well as Valsalva manoeuvres (LUDIN 1962 FRIEDENBERG et coll 1965), have also been practised LUDIN (1966) observed symptoms from the spinal cord in patients examined during Valsalva manoeuvres The same dose of Urografin did not cause any complication if injected with the caudal part of the patient lowered A retarded blood flow will cause layering of the medium (KJELLBERG 1943 NORDENSTROM 1960, Fox et coll 1964) so that its direction can be affected It is therefore important to protect the more sensitive organs especially the central nervous system and the kidneys when angiography is performed during retarded circulation The risks of a high dose of contrast medium as in angiography may be diminished if the head is raised and the examination performed prone Excessive layering of the contrast medium to the dorsal spinal renal carotid and vertebral arteries is then avoided

A method of contracting the renal capillaries during aortography with epinephrine or nor epinephrine has been used (ABRAMS et coll 1962) During this procedure the risk of spinal cord injury is increased (LINDVALL 1967) an effect that has been examined by MARGOLIS et coll (1966) The vasodepressor agents may cause a stronger contraction of the splanchnic and the dorsal muscle arteries than the less easily influenced dorsal spinal arteries and thus prolong the application time to the spinal cord Discussing the role of epinephrine the finding by REDMAN et coll (1966) has to be mentioned After selective injection in the renal artery of epinephrine pathologic changes were seen The changes were more severe if the injection was followed by an injection of Urografin 76 % and the authors suggest the possibility that epinephrine my alter the cellular permeability

Renal damage during aortography was compared with neurologic damage by KILLEN et coll (1962) These authors stated that with sodium acetrizoate the spinal cord injury during clinical aortography is unpredictable and in many instances has been within the usual recommended dosage range, and that the majority of instances of renal injury sustained during sodium acetrizoate aortography have been associated with the use of amounts of Urokon greater than the usual recommended dosage The spinal cord thus seems to be more sensitive than the kidney and the result of the present investigation of the toxicity to the nervous system also applies to toxicity to the kidney The abdominal aorta was occluded below the renal arteries in only two cases in this series The toxicity of media to the kidney was not investigated As previously mentioned, a comparison was also made by KILLEN et coll of doses given to dogs causing injury to the spinal cord and kidneys with those to human subjects who developed complications as reported in the literature The dog seemed to be more sensitive than man The assumption may therefore perhaps be made that doses proved tolerable in dogs are also tolerable in man

tered microscopic foci of destruction, affecting gray or white matter, present in one or more sections of the spinal cord In some cords only a focal or diffuse glial hyperplasia within the gray substance was observed

The animals in this investigation were controlled for a long time after aortography No late neurologic signs developed The observation time for the dogs in which sodium diatrizoate was injected varied between a month and a year

Repeat injections in man with the most concentrated contrast media may cause spinal cord or renal damage in cases of pathologic occlusion of the aorta, for instance in cases of dissecting aneurysm and the Leriche syndrome (GROSSMAN et coll 1958, OLSSON 1961) Doses in aortography of such cases should therefore be restricted

Smaller doses of media may cause damage if the injection in error is made selectively into an artery that supplies the spinal cord The so-called arteria radicularis magna at the level of L 1—L 2 has the widest diameter but every intercostal artery bears a spinal branch

In selective angiography in man of the bronchial or intercostal arteries, with the technique described by NORDENSTROM (1967), VIAMONTE (1964), and BOIJSEN et coll (1965), repeat injections of highly concentrated media may cause damage to the spinal cord No complication has been reported by VIAMONTE, or BOIJSEN, but in one of NORDENSTROM s cases several repeat injections into the same intercostal artery of 15 ml sodium methylglucamine diatrizoate (Urografin) 76 % caused slight hemiparesis, which lasted for 24 hours and then disappeared FEIGELSON et coll (1965) has also published a case of paresis of the right leg in a human subject after selective bronchial arteriography He supposed the cause to be allergic, but a toxic effect of the medium on the spinal cord is a more probable explanation

It is important in routine work to remember that there is a risk in repeating injections of high concentrations of media above an occluded aorta or into one with a retarded blood flow as well as into small vessels supplying the spinal cord The tolerance of a contrast medium is of importance not only during occlusion of the aorta but also during retardation, deliberate or unintentional, of the blood stream in the aorta, or the arteries arising from the aorta and supplying the central nervous system The retardation may cause a prolonged application of the medium to the tissues and in that way increase the risk of damage (BROMAN et coll 1950) Retardation of the blood stream in the aorta in radiologic work nowadays may be obtained by increasing the intrabronchial pressure (BOEREMA et coll 1955, NORDENSTROM 1960), or by occlusion of the superior or especially the inferior vena cava (NORDENSTROM 1955) Cardiac arrest and hypotension by means of acethylcholine (ARNULF 1958), preparations of trimethaphan (Arfo-

SUMMARY

Aortography with occlusion of the aorta in dogs was found to raise the risk of damage to the spinal cord considerably as compared to aortography during free circulation. Two injections above the occlusion, each of 1 ml/kg bodyweight of one of the least toxic of the contrast media, caused severe irreversible damage to the spinal cord, as was also the case when the hypertonic saline was used. It is pointed out that also other methods of changing the circulation during angiography may be connected with risks of injury to the spinal cord.

ZUSAMMENFASSUNG

Aortographie an Hunden mit Blockierung der Aorta ist mit erheblich grosserem Risiko von Ruckenmarkschadigung verbunden als wenn Aortographie wahrend freier Zirkulation durchgefuhrt wird. Zwei Injektionen oberhalb der Blockierung, jede von nur 1 ml/kg Korpergewicht eines der wenigst toxischen Kontrastmitteln, fuhrten zu schweren und dauernden Ruckenmarkschaden. Auch andere Methoden die Veranderungen der Zirkulation wahrend Angiographie hervorbringen konnen mit Risiko von Ruckenmarkschadigung verbunden sein.

RÉSUMÉ

L'aortographie avec obstruction de l'aorte sur des chiens augmente considérablement le danger de lésion de la moelle epinière par rapport à l'aortographie en circulation libre. Il suffit d'injecter 1 ml/kg de poids d'un des moyens de contraste les moins toxiques au dessus de l'obstruction pour causer de graves lesions irreversibles de la moelle epinière. L'auteur souligne que les autres methodes qui modifient la circulation pendant l'angiographie peuvent augmenter le danger de lesion medullaire.

REFERENCES

ABRAHAM J, MARGOLIS G, O'LOUGHLIN J C et coll. Differential reactivity of neural and extra neural vasculature. I. Role in the pathogenesis of spinal cord damage from contrast media in experimental aortography. J Neurosurg 25 (1966) 257.

ABRAMS H L, BOIJSEN E and BORGSTROM K E. Effect of epinephrine on the renal circulation. Angiographic observations. Radiology 79 (1962) 911.

ALLBAUGH E and HORVATH S M. Effect of total occlusion of thoracic aorta on blood pressure, splanchnic blood flow and metabolic state in dogs. Amer J Physiol 180 (1954) 451.

ALMÉN T. A steering device for selective angiography and some vascular and enzymatic reactions observed in its clinical application. Acta radiol (1966) Suppl No 260.

ARNULF G and CHACRONAC R. L'arteriographie méthodique des arteres coronaires grace a l'utilisation de l'acethylcholine, donnees experimentales et cliniques. Lyon chir 54 (1958) 212.

BERG N O, IDBOHRN H and WENDEBERG B. Investigation of the tolerance of the rabbit's kidney to newer contrast media in renal angiography. Acta radiol 50 (1958) 285.

BERNSTEIN E F and EVANS R L. Low molecular weight dextran. J.A.M.A. 174 (1960) 1417.

BLAISDELL F W and COOLEY D A. The mechanism of paraplegia after temporary thoracic aortic occlusion and its relationship to spinal fluid pressure. Surg 51 (1962) 351.

Two case reports of paralysis after lumbar aortography with moderate doses of sodium diatrizoate in human subjects constitute evidence against the present results (TINGAUD et coll 1961, WEINGARTEN 1962) From the data given it cannot be excluded that the contrast medium may inadvertently have been injected into the arteria radicularis magna or that the needle on insertion may have produced mechanical injury to this artery

The possibility of diminishing the toxicity of contrast media by injection of other substances before aortography was not considered in this investigation It is in any case important to know the toxicity of the medium itself KENAN et coll (1958), BERNSTEIN et coll (1960), and KILLEN et coll (1962) and YERASIMEDES *et coll (1963) have demonstrated diminished toxicity if procaine, glucose, low* molecular weight dextran, or vasodepressor agents are injected before aortography is performed MARGOLIS et coll (1966) observed on the contrary increased toxicity to the spinal cord of one of the least toxic media, the diatrizoate compounds, when vasopressor agents (nor epinephrine) were previously injected

The etiology of spinal cord damage by contrast media is perhaps more complicated than was earlier supposed (MARGOLIS et coll 1966) Originally, most authors described the effect as a direct chemotoxic action upon the central nervous tissue after the blood brain barrier had been broken MARGOLIS et coll (1959) and READ (1959), followed by others, observed the changes in the peripheral circulation and erythrocyte aggregation after injections of contrast media *The latter author explained the changes as caused by the hypertonicity* Thus, to obtain an idea about the role of other hypertonic solutions in causing spinal cord damage, hypertonic sodium chloride was injected in a dog The sodium concentration was the same as that of Angio Conray, the medium with the highest available iodine concentration As seen in the results this saline solution caused spinal cord damage of the same type as roentgen contrast media With modern media it is difficult to know how much damage to the spinal cord may be caused by a direct neurotoxic effect and how much by anoxemia secondary to circulatory disturbances in the vessels of the spinal cord

The same conclusion may be drawn from this report as from another on bradycardial reactions during carotid angiography (TORNELL to be published) that the sodium salts of modern media (sodium diatrizoate, metrizoate or iothalamate) have no higher toxic effects than sodium chloride of a similar tonicity So the possibility of finding less toxic media does not appear to lie in the synthesis of a new anion

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matique de la tolérance des capillaires cérébraux pour les produits de contraste utilisés en artériographie Acta radiol (1967) Suppl No 270 p 228

GRAYSON T MARGULIS A R MEINBECKER P and SALTZSTEIN S L Effects of intra arterial injection of Miokon Hypaque and Renografin in the small intestine of the dog Radiology 77 (1961) 777

GROSSMAN L A and KIRTLEY J A Paraplegia after translumbar aortography J A M A 166 (1958) 1035

HARE W S C Damage to the spinal cord during translumbar aortography J Fac Radiol 8 (1957) 258

HELANDER C G Nephrographic effect and renal arteriographic damage An experimental study Acta radiol (1958) Suppl No 163

HENLINE R B and MOORE S W Renal arteriography Preliminary report of an experimental study Amer J Surg 32 (1936) 222

HILAL S K Hemodynamic changes associated with the intra arterial injection of contrast m dia New toxicity tests and a new experimental contrast medium Radiology 86 (1966) 615

HOL R and SKJERVEN O Spinal cord damage in abdominal aortography Acta radiol 42 (1954) 276

HUGER W E MARGOLIS G and GRIMSON K S Protective effect of intraaortic injection of procain against renal injuries produced in experimental aortography Surgery 43 (1958) 52

JONSSON G BRODEN B and KARNELL J Thoracic aortography Acta radiol (1951) Suppl No 89 p 11

KENAN P D TINDALL G T MARGOLIS G and WOOD R S The prevention of experimental contrast medium injury to the nervous system J Neurosurg 15 (1958) 92

KILLEN D A and FOSTER J H Spinal cord injury as a complication of aortography Ann Surg 152 (1960) 211

— — Severity of renal injury incident to abdominal aortography Effect of concentration of contrast solution Arch Surg 87 (1963) 650

— — Spinal cord injury as a complication of contrast angiography Surgery 59 (1966) 969 (Extensive list of references)

— and LANCE E M Significance of repeat injection of contrast medium in the geneses of kidney and sp nal cord damage resulting from abdominal aortography Ann Surg 152 (1960) 231

— FOSTER J H and SCOTT H W Toxic reactions incident to Urokon aortography as related to the volume of contrast medium injected Ann Surg 155 (1962) 472

— LANCE E M and OWENS G Relative suitability of Urokon 70 % and Hypaque 90 % for use as aortograph c contrast media Surgery 45 (1959) 436

KJELLBERG S R Die Mischungs- und Stromungsverhaltnisse von wasserloslichen Kontrast mitteln bei Gefass- und Herzuntersuchungen Acta radiol 24 (1943) 433

LINDGREN P Renal circulatory insufficiency after renal angiography An experimental study Acta radiol 56 (1961) 423

— and TORNELL G Blood circulation during and after peripheral arteriography Acta radiol 49 (1958) 425

— SALTZMAN G F and TORNELL G Vascular reaction to watersoluble contrast media Significance of concentrat on and total amount of iodine Acta radiol Diagnosis 7 (1968) 152

LINDVALL N Pharmakoangiographie bei Nierencarcinom und Nierenbeckentumoren Der Urologe 6 (1967) 1 6

BOEREMA I and BLICKMAN J R Reduced intrathoracic circulation as an aid in angiocardiography, experimental study J thorac Surg 30 (1955), 129

BOIJSEN E und OLIN T Zoliakographie und Angiographie der Arteria mesenterica superior *In* Schinz Glauner Ruttiman Ergebnisse der medizinischen Strahlenforschung Neue Folge Band 1 Thieme Verlag Stuttgart 1964

— and ZSIGMOND M Selective angiography of bronchial and intercostal arteries Acta radiol Diagnosis 3 (1965) 513

BROMAN T and OLSSON O The tolerance of cerebral blood vessels to a contrast medium of the Diodrast group An experimental study of the effect on the blood brain barrier Acta radiol 30 (1948) 326

— — Experimental study of contrast media for cerebral angiography with reference to possible injurious effects on the cerebral blood vessels Acta radiol 31 (1949) 321

— FORSMAN B and OLSSON O Further experimental investigations of injuries from contrast media in cerebral angiography Summations of various factors Acta radiol 34 (1950) 135

BURCH B H TRAPHAGEN D W and FOLKMAN M J The use of aortic occlusion in abdominal surgery with a report of two human cases Surgery 34 (1953) 672

— — — ROSENBAUM D A and MUELLER E C Temporary aortic occlusion in abdominal surgery Surgery 35 (1954) 684

BURTON OPITZ R The venous supply of the heart Amer J Physiol 58 (1921) 226

CARREL A On the experimental surgery of the thoracic aorta and the heart Ann Surg 52 (1910) 83

COOLEY R N SCHREIBER M H and BROWN R W Effects of transaortic catheter injection of Renografin Urokon Hypaque and Miokon into the superior mesenteric arteries of dogs Angiology 15 (1964) 107

DOTTER Ch T and FRISCHE L H Visualization of the coronary circulation by occlusion aortography A practical method Radiology 71 (1958) 502

EDWARDS W S SALTER P P and CARNAGGIO V A Intraluminal aortic occlusion as a possible mechanism for controlling massive intraabdominal hemorrhage Surg Forum 4 (1954) 496

FEIGELSON H H and RAVIN H A Transverse myelitis following selective bronchial arteriography Radiology 85 (1965) 663

FLOM R S McLEAN L D and LEWIS F J A comparison of the toxicity of various agents used in coronary arteriography J Lancet 77 (1957) 431

FOSTER J H KILLEN D A SESSIONS R T et coll The relative toxicity of angiographic contrast media Vascular diseases 1 (1964) 8

FOX J A and HUGH A E Some physical factors in arteriography Clin Radiol 15 (1964) 183

FRIEDENBERG M J and CARLSSON E Bilateral aorto ilio femoral arteriography via a unilateral common femoral artery needle Acta radiol Diagnosis 3 (1965) 1

FUJI K GRAYSON T MARGULIS A R and SALTZSTEIN S L The effect of intra arterial injection of contrast media on canine intestine Amer J Roentgenol 89 (1963) 730

GIDLUND Å Development of apparatus and methods for roentgen studies in haemodynamics Acta radiol (1956) Suppl No 130

GIUSEFFI J GREENE L W and VETTO M Experiments on occlusion of the abdominal aorta in normothermic dogs Surg Gynec Obstet 105 (1957) 427

GOBBEL JR W G DALTON J B TAYLOR W L et coll Beneficial effects of inferior vena caval occlusion when the thoracic aorta is occluded Surg Forum 8 (1958) 406

GONSETTE R et ANDRE BALISAUX G La perméabilité des vaisseaux cérébraux Etude systé

READ R Cause of death in cardioangiography J thorac cardiovasc Surg 38 (1959) 685

REDMAN H C OLIN T B SALDEEN T and REUTER S R Nephrotoxicity of some vasoactive drugs following selective intra arterial injection Invest Radiol 1 (1966) 458

RHEA W G O NEILL J A KILLEN D A and FOSTER J H Toxic reactions incident to *aortography The hazard of repeat injection* Circulation 29 (1964) 161

SALVESEN S LUND NILSEN P and HOLTERMANN H Effects of calcium and magnesium ions on the systemic *and local toxicities of the N methyl glucamine (meglumine) salt of metrizoic* acid (Isopaque) Acta radiol (1967) Suppl No 270 p 180

SCATCLIFF J H SIMAREK S CUTLER L and LARSEN P B Angiography of the celiac axis Radiology 78 (1962) 215

STENO Cited by ANTONI N and LINDGREN E Steno s experiment in man Acta chir scand 98 *(1949) 230*

STEWART B H DUNSON R L FERGUSON C F and SHEPHARD P H Experimental renal arteriography comparison of spinal cord and renal toxicity from iothalamate and diatrizoate compounds J Urology 94 (1965) 695

TINDALL G T KENAN P D PHILLIPS R L et coll Evaluation of roentgen contrast agents used in cerebral arteriography J Neurosurg 15 (1958) 37

TINGAUD R PAULY R et MAUPIN J A propos d un cas de paraplégie apres aortographie *abdominale J Med* Bordeaux 138 (1961) 1294

TORNELL G Bradycardial reactions in cerebral angiography induced by sodium and methyl glucamine iothalamate *(Conray) Comparison with Urografin in a controlled study in* man Acta radiol Diagnosis 7 (1968) 489

VIAMONTE M Selective bronchial arteriography in man Preliminary report Radiology 83 (1964) 830

VOSSE A Étude expérimentale de la tolérance des produits de contraste triiodés par la barriere hématocérébrale Rev méd Liège 15 (1960) 645

WATKINS E Circulatory changes produced by clamping of the thoracic aorta Surgery 22 *(1947) 530*

WEINGARTEN K Über neurologische Komplikationen nach Aortographie Wien Z Nerven *heilk 20 (1962) 257*

YERASIMEDES T G MARGOLIS G and LONTON H J Prophylaxis of experimental contrast medium injury to the spinal cord by vasopressor drugs Angiology 14 (1963) 394

LUDIN H Aortographie unter Valsalva Bedingungen Fortschr Rontgenstr 96 (1962), 611
— Aortography fluid dynamics and technical problems Acta radiol (1966) Suppl No 256
LUNDERQUIST ANDERS Angiography in carcinoma of the pancreas Acta radiol (1965) Suppl No 235
MARGOLIS G and YERASIMIDES T G Vasopressor potentiation of neurotoxicity in experimental aortography Implications regarding pathogenesis of contrast medium injury Acta radiol Diagnosis 5 (1966) 388
— TARAZI A K and GRIMSON K S Contrast medium injury to the spinal cord produced by aortography pathologic anatomy of the experimental lesion J Neurosurg 13 (1956) 319
— GRIFFIN A T KENAN P D et coll Contrast medium injury to the spinal cord The role of altered circulatory dynamics J Neurosurg 16 (1959) 390
— TINDALL G T PHILLIPS R L et coll Evaluation of roentgen contrast agents used in cerebral arteriography J Neurosurg 15 (1958), 30
MIKAELSSON C G Polythene catheter of new shape for percutaneous selective catheterization Acta radiol Diagnosis 3 (1965) 581
MORRIS S E LASSER E C FISCHER B et coll A comparative experimental approach to contrast materials in renal angiography Radiology 77 (1961) 764
MOYER J H HEIDER C MORRIS JR C G and HANDLEY C Renal failure I The effect of complete renal artery occlusion for variable periods of time as compared to exposure to subfiltration arterial pressures below 30 mm Hg for similar periods Ann Surg 145 (1957) 41
NANSON E M NOBLE J G and EMSON H The effect on the kidneys of cross clamping the aorta distal to the renal arteries Surg Forum 9 (1959) 317
NORDENSTROM B Temporary unilateral occlusion of the pulmonary artery Acta radiol (1954) Suppl No 108
— A method of angiography of the azygos vein and the anterior internal venous plexus of the spine Acta radiol 44 (1955) 201
— Contrast examination of the cardiovascular system during increased intrabronchial pressure Acta radiol (1960) Suppl No 200
— Therapeutic roentgenology A preliminary report on the selective application of cytostatics and the transthoracic needle coagulation of bronchial carcinomas Acta radiol Diagnosis 3 (1965) 115
— Selective catheterization and angiography of bronchial and mediastinal arteries in man Acta radiol Diagnosis 6 (1967) 13
— and TORNELL G Possibilities of angiography during temporary occlusion of the aorta in man Acta radiol Diagnosis 4 (1966) 321
OLIN T B and REDMAN H C Experimental evaluation of contrast media in the vertebral circulation Acta radiol (1967) Suppl No 270 p 216
— and REUTER S R A pharmacologic method for improving nephrophlebography Radiology 85 (1965) 1036
OLSSON O Technique and hazards of renal angiography *In* Angiography Edit by H L Abrams Little Brown & Co Boston 1961
PARKINS W M, BEN M and VARS H M Tolerance of temporary occlusion of the thoracic aorta in normothermic and hypothermic dogs Surgery 38 (1955) 38
PINET F GRAVIER J et PINET A Une méthode nouvelle d aortographie L angiographie sous hypotension contrôlée par le campho sulfonate de trimétaphane Sem Hop Paris 35 (1959) 1855
RAFFUCCI F L and WANGENSTEN O H Tolerance of dogs to occlusion of entire afferent vascular inflow to the liver Surg Forum 1 (1951) 191

READ R Cause of death in cardioangiography J thorac cardiovasc Surg 38 (1959) 685

REDMAN H C OLIN T B SALDEEN T and REUTER S R *Nephrotoxicity of some vasoactive* drugs following selective intra arterial injection Invest Radiol 1 (1966) 458

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Book reviews

RÖNTGENOLOGISCHE HERZVOLUMENBESTIMMUNG IN KLINIK UND PRAXIS Von H Klepzig und P Frisch 56 Seiten 26 Abbildungen in 77 Einzeldarstellungen 9 Tabellen und 2 Nomogramme G Thieme Verlag Stuttgart 1965 Preis 18 DM

This consists of a brief survey of methods and technique of determination of heart volume roentgenologically The various physiologic and pathologic factors that may influence the size of the heart the magnitude of the errors inherent in the methods of determination and the clinical implication of the assessment of heart volume are all discussed The facts presented are clearly stated the text is lucid and reproductions of the roentgenograms are invariably of high quality The section on the prognostic significance of serial studies of heart volume is however rather fragmentary and reference should have been made to P Amundsen s important work on the subject the references listed otherwise appear to be well chosen This will form an adequate guide for those who are unfamiliar with the methods and the value of roentgenologic determinations of the heart volume

Ulf Rudhe

LA DIAGNOSTICA RADIOLOGICA DELLE SUPPURAZIONI BRONCO POLMONARI By Dario Gandini and Gian Luca Sannazzari Edizioni Minerva Medica Turin 1965 401 pages including 33 pages of references and 352 illustrations Price 18 000 lires

This book which contains a preface by Professor Enrico Bonassi deals with the roentgenologic appearances of bronchopulmonary suppurations It is more an atlas than a treatise or a monograph though the authors survey the clinical etiologic and pathologic aspects of each group of disease discussed Bronchitis with or without respiratory difficulties bronchiectasis congenital or acquired and pulmonary abscesses are reviewed in turn There are numerous illustrations for each of these groups and they are presented side by side on two opposite pages so that case histories and roentgenologic findings may easily be compared Most of the illustrations are composite figures including conventional films tomograms and bronchograms obtained with Lipiodol injection In addition kymograms and cineradiographic films illustrate some diseases Emphasis is placed on the importance of kinetic studies of the bronchi which are facilitated by kymography or cineradiography but if such modern means are not available it is recommended to obtain two films one during inspiration and the other during expiration with Lipiodol in the bronchi

The book represents a well documented atlas of high quality The illustrative cases are well chosen and have been thoroughly studied They may well be expected to render good service for reference purposes and should be of great interest to radiologists and pneumologists It is highly recommended

D Madray Toulouse

BILDGUTE IN DER RADIOLOGIE Symposion am 1 und 2 Oktober 1964 auf der Insel Herrenchiemsee/Obb Herausgegeben von Friedrich Ernst Stieve 415 Seiten 197 Abbildungen 16 Tafeln und 21 Tabellen Gustav Fischer Verlag Stuttgart 1966 Preis 55 DM

This publication with Professor Stieve of Munich as editor and H Schober H Fischgold and G Spiegler as consultants is the outcome of an attempt to collect the complete series of papers including discussions and references in book form The subject matter is important since m ny rad olo,ists eem to be insufficiently informed and misleading opinions are often expressed O Loughl n stresses that a radiologist often asks how can I get the best radiologic result with the lowe t possible dose and what do I really obtain for my money?

The radiographic definition of certain details can be studied mathematically but the analyses of a roentgenogram and the recognition of diagnostically valuable details are more complicated problems connected w ith psycho physical factors Many aspects of the radio graphic interpretation are impossible to analyse objectively only definition contrast density radiographic mottle and dose factors can be determined mathematically

The meaning of image quality is discussed but most attention has b en given to defini tion and contrast which are more easily measured Tuddenham s opinion regarding radio graphic quality is interesting Image quality is not related to what is esthetically beautiful nor to diagnostic efficiency Line spread functions are preferred for the purely technical analysis of equipment

Bildgute was introduced as an expression for the combined factors Spiegler discusses Bildgute with respect to dosage under different conditions such as high and low kilovolt ages In the chapter on radiation relief is included a consideration of extra focal radiation among other stray radiation ources The important close to-focus principle seems to have been forgotten however

Various types of phantoms for quality studies are dealt with by Frik and the physical factors involved in the recording of details and analyses of the radiation reliefs of objects are presented by Rohler O Schott considers image quality and the modulation transfer function (MTF) in radiology The common mistake of applying the modulation transfer function to nonlinear systems is made It must be remembered that as soon as photography is in olved no linearity between exposure and density exists so that the functions used are of no account De Winter presents studies of the function in different parts of the image intensifying system Hofert discusses problems connected with photographic grain screen thickness etc while M de Belder considers stray radiation (stray light) within the film layer and screens Kos el gives an informative presentation of the recent po ition regarding the xeroradiographic procedure He stresses that the very pecial character of the xero radiographic image may cause problems of analysis even for a trained radiologist This aspect is important for as soon as a new recording system appears the experiences gained from current conventional systems become insufficient and new conceptions become necessary

Certain pr nciples of harmonizing and contra t enhancing are discussed by Gajewski The import nt phy iol gy of vision is presented in relation to radiography by Schober and Hartman discus es the physiology of examining roentgenograms in viewing lanterns The resolution f miniature and full ize chest films are compared by Nawijn and problems connected with che t radiography and the resolution of detail in lung tissues are considered by Stieve Van Ronnen and Feddema discu s the use and limitation of conventional fluoroscopy and that performed by a TV chain Keane deals with image quality in stereoscopy

The book includes brief explanations to some of the more commonly employed photographic and scientific terms and contains a list of authors, their occupation and earlier scientific work

Ove Mattsson

EINFUHRUNG IN DIE RONTGENDIAGNOSTIK Von U Cocchi und P Thurn 2 neubearbeitete und erweiterte Auflage 378 Seiten mit 484 Abbildungen in 615 Einzeldarstellungen und 14 Tabellen G Thieme Verlag Stuttgart 1967 Preis 49 50 DM

The second edition of this well known introduction to roentgen diagnostics is published eight years after the appearance of the original edition The main emphasis has been laid on numerous instructive and excellent reproductions of roentgenograms These are as a rule properly aligned to the running text and several of them are supplemented by highly informative drawings The sections of traumatology disorders of the kidney spleen and liver the retroperitoneal space and the mammary glands have been revised and partially re written These chapters well reflect the changing perspectives of roentgenologic practice over the past years It is however to be regretted that the technique and application of roentgenologic heart volume determination micturition urethrocystography and cineradiography are mentioned only in passing and the videotechnique not at all A minor point is that the heart illustrated in Fig 289 which is stated to demonstrate Fallot s tetralogy with dextroversion suggests to the reviewer a form of corrected transposition of the great vessels with dextrocardia

The authors state in the preface that the book is designed to introduce medical students and clinicians into the fundamentals of roentgen diagnostics It is therefore important that the terminology should be precise It is regrettable that loose non roentgenologic terms present in the first edition of the book are retained in the new version Expressions such as flachenhafte Verdichtungen Fleckschatten Herzschatten and Aortenknopf are entirely inadequate in that they convey an erroneous concept of the underlying anatomy and do not take into account the roentgenogram being essentially an absorption diagram These criticisms are not only of academic interest but have a much wider application It is inevitable that they greatly detract from the value of the book

Ulf Rudhe

RADIOLOGY IN NEURO OPHTHALMOLOGY By Guido Lombardi 224 pages 167 figures and 26 tables Williams & Wilkins Co Baltimore 1967 Price 13 25 dollars

The author points out in the introduction that neuro ophthalmology is a meeting point of many specialities Visual disturbances may be caused by lesions different in nature and location The correct diagnosis is often made too late when damage is already irreparable The radiologist is in a key position since the correct diagnosis in many of these lesions is mainly based on the result of his examinations He should be well acquainted with the various methods available and be able to choose the best method in a given case and to

evaluate the findings correctly In current radiologic textbooks methods for contrast examination of the orbit are *only briefly described* The chapter devoted to these methods — orbitography arteriography and venography — therefore fills a great need Techniques as well as the normal anatomy are clearly described and illustrated Possible complications in each are also *includ d For orbitography the* author apparently prefers water soluble con*trast media to gas* He reports no permanent sequelae with these in the material he has mentioned in a personal communication however that he recently had a case in which *permanent blindness occurred* The chapters that follow include reports upon practically every radiographically demonstrable lesion that may cause ophthalmologic signs — tumours in various locations inflammatory and vascular lesions malformations and injuries

The *numerous illustrations* mostly from the author s large and well documented material fulfill their purpose adequately they are generally of good quality and the changes described are always evident A fairly extensive bibliography appears at the end of each chapter

The author's style is concise so that the text is easy to read The book may be highly recommended not only to neuroradiologists but to all who are interested in ophthalmology and neuroradiology

I Wickbom

Hysterosalpingography By Alvin M Siegler 406 pages and 543 figures Hoeber Medical Division Harper & Row Publishers New York Evanston and London 1967 Price *12 dollars*

The gynecologist responsible for this comprehensive and profusely illustrated work has doubtless had considerable experience of hysterosalpingography and is well acquainted with the literature on the subject The presentation is however unfortunately influenced by the fact that his knowledge of modern roentgenologic techniques appears to be somewhat incomplete The book contains a great deal of information which is valuable particularly because of the author s objective way of looking at things A good survey of the range of applications of the method of hysterosalpingography is exemplified and illustrated The author s consideration of salpingography as a test for tubal patency and his investigations *on the reliability of the* CO_2 *test are further useful contributions*

The illustrations may in the main be described as unsatisfactory and sometimes wholly objectionable This refers especially to material borrowed from other sources (for example Fig 6 12 on page 179) and *seems to bear evidence to the author s* failure to appreciate the importance of properly illustrating and clarifying doubtful points The author s own illustrations are however not of a high standard This may be due in some degree to the fact that his films are mainly from examinations performed with contrast *media of the* iodized oil type although it must also be the result of an inadequate technique Even conventional photographs of the specimens are of inferior quality (for example Fig 7 9 on page 198 which should illustrate synechia of the uterine cavity)

This cannot be said to represent a roentgenologic textbook on the subject

Ingmar Fernstrom

ILEUS UND ILEUSARTIGE ZUSTANDE IM FRÜHEN KINDESALTER. ABDOMINALE LEERAUFNAHME. Von A. Rubin. 74 Seiten, 110 Bilder, 1 Tabelle. Georg Thieme Verlag, Stuttgart 1967. Price 44 DM.

This work is based on observations in about 300 newborn and young infants submitted to roentgen examination for possible ileus or ileus-like complaints. Many conditions, as for instance atresia of the esophagus, pneumoperitoneum, and water intoxication, have been included under this heading which, according to the accepted medical terminology, would not have been expected.

The author has primarily concentrated his attention on the findings in logic criteria for interpretation of the films in different ileus conditions. He does not, however, state clearly what relative or absolute value he places on the different observations, nor in which cases he considers it possible to rely solely on this examination. Despite the fact that, according to the author, the localization and cause of ileac conditions in infants can be established with complete certainty by using abdominal conventional films alone, this examination was remarkably often supplemented with contrast studies, a measure which in the reviewer's opinion was often well justified. The author does not, however, indicate his reasons for doing so, although in view of the remark quoted above this information would have been of interest. Nor does he discuss his choice of examination method or contrast medium.

Such omissions, which occur throughout the book, leave the reader in some uncertainty as to which method the author considers best for different conditions. In connection with the problems of invagination, for instance, he states that it is often difficult to make an accurate diagnosis with conventional roentgenography alone, and mentions the possibilities offered by a diagnostic and therapeutic enema. Whether he prefers surgical treatment to a therapeutic enema is equally as obscure as his views on the indications for and against the two measures. That the author is far away from the premises that have long been considered standard in Scandinavian radiology is evident from the fact that he often leaves the decision to the pediatrician or the surgeon when a supplementary roentgen examination would have been the logical measure. This occurs, for instance, in establishing the level of an anal atresia; such information, which is of great importance to the surgeon, can seldom be obtained from conventional films alone, whereas voiding urethrocystography often supplies the decisive data.

For those with little experience in pediatric roentgenology the book provides an extensive survey of pathologic states that often produce abdominal signs. For pediatric radiologists with wider experience, the absence of definite systematic declarations of the author's preferences is a considerable weakness in this otherwise typographically attractive little volume.

Ole Eklöf

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EFFECT OF PRETREATMENT WITH DEXTRAN 70 ON PLATELET ADHESIVENESS AND THROMBOEMBOLIC COMPLICATIONS FOLLOWING PERCUTANEOUS ARTERIAL CATHETERISATION

by

BO JACOBSSON

Percutaneous arterial catheterisation is now widely used especially in diagnostic roentgenology. Thromboembolism is the commonest serious complication. It has recently been shown (JACOBSSON & SCHLOSSMAN 1969a) that the risk of complications varies with the area of the outer surface of the intravascular part of the catheter. This suggests that thrombus formation is stimulated by some reaction of the blood with the surface of the catheter. Subsequent in vitro experiments have shown that platelets adhere to the catheter and aggregate (JACOBSSON 1969a). Such a reaction is the initial step in the formation of thrombi (HUGUES 1962, OWREN 1964, MUSTARD et coll. 1967) and presumably involves a risk of thrombus formation on catheters placed in the blood stream. It was demonstrated in dogs (JACOBSSON et coll. 1969a) that platelets adhered to vascular catheters with thrombus formation as a result; thrombi on catheters placed in human blood vessels have also been demonstrated (JACOBSSON & SCHLOSSMAN 1969b).

From the Departments of Roentgen I (Director: Prof. O. Bartley) and Surgery I (Director: Prof. L. E. Gelin), Sahlgrenska Sjukhuset, Gothenburg, and the Coagulation Laboratory (Director: Prof. I. M. Nilsson), Allmanna Sjukhuset, Malmo, Sweden. Supported by grants from the Swedish National Association against Heart and Chest Diseases. Submitted for publication 17 December 1968.

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The author has primarily concentrated his attention on the findings in logic criteria for interpretation of the films in different ileus conditions He does not however state clearly what relative or absolute value he places on the different observations nor in which cases he considers it possible to rely solely on this examination Despite the fact that according to the author the localization and cause of ileac conditions in infants can be established with complete certainty by using abdominal conventional films alone this examination was remarkably often supplemented with contrast studies a measure which in the reviewer s opinion was often well justified The author does not however indicate his reasons for doing so although in view of the remark quoted above this information would have been of interest Nor does he discuss his choice of examination method or contrast medium

Such omissions which occur throughout the book leave the reader in some uncertainty as to which method the author considers best for different conditions In connection with the problems of invagination for instance he states that it is often difficult to make an accurate diagnosis with conventional roentgenography alone and mentions the possibilities offered by a diagnostic and therapeutic enema Whether he prefers surgical treatment to a therapeutic enema is equally is obscure as his views on the indications for and against the two measures That the author is far away from the premises that have long been considered standard in Scandinavian radiology is evident from the fact that he often leaves the decision to the pediatrician or the surgeon when a supplementary roentgen examination would have been the logical measure This occurs for instance in establishing the level of an anal atresia such information which is of great importance to the surgeon can seldom be obtained from conventional films alone whereas voiding urethrocystography often supplies the decisive data

For those with little experience in pediatric roentgenology the book provides an extensive survey of pathologic states that often produce abdominal signs For pediatric radiologists with wider experience the absence of definite systematic declarations of the author s preferences is a considerable weakness in this otherwise typographically attractive little volume

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On withdrawal of the catheter through the vessel wall, the thrombi were found to be wiped off, which resulted in the formation of thrombotic masses at the site of puncture This may explain the thromboembolic complications occurring after catheterisation

The formation of thrombi is therefore probably due to the properties of the material from which the catheter is made An ideal material for catheters would thus be one to which platelets do not adhere, but since no such composition seems to be available, some other approach must be tried

Previous studies (AHLBERG et coll 1968, ATIK 1968, JOHNSON et coll 1968) have indicated that dextran counteracts thrombus formation This has been ascribed to the ability of dextran to decrease platelet adhesiveness (BYGDEMAN et coll 1966, ATIK 1968) and thereby to prevent the first phase in the formation of thrombi The purpose of the present study was to investigate the effect of dextran on platelet adhesiveness and thrombus formation after percutaneous arterial catheterisation Since the frequency of thromboembolism in this department is highest following coronary angiography, and since catheterisation for this examination is followed by a rapid increase in the adhesiveness of the platelets (JACOBSSON 1969b), it was decided to carry out the examination in patients undergoing such angiography

Material and Methods Coronary angiography was performed according to the method of PAULIN (1964), with radiopaque polythene catheters (Kifa grey) and percutaneous catheterisation of the femoral artery The intended site of puncture was anaesthetised with 10 to 20 ml of 1 % Carbocain ® No pre medication was given The patients were afterwards examined for thrombo-emboli with oscillography in the manner described earlier (JACOBSSON et coll 1969b)

Two groups of patients were studied one with and one without pretreatment with dextran (Macrodex ®) The two groups did not differ from one another as to age and sex distribution, time of examination, treatment with anti coagulants, and coronary disease (Table 1) The control group consisted of 77 consecutive patients examined between 1 September 1965 and 31 December 1966 The group that received dextran 70 consisted of 85 consecutive patients examined between 1 January 1967 and 1 October 1968 These patients received 10 ml of 6 % dextran 70 per kg bodyweight intravenously The dose was given during a period of 2 to 4 hours and coronary angiography was carried out 1 to 2 hours after the termination of infusion The adhesiveness of the platelets was repeatedly determined in 36 randomly selected patients belonging to this group The results of a similar investigation of the untreated group will be published elsewhere (JACOBSSON 1969b)

Table 1

Comparison of two consecutive series of patients undergoing coronary angiography

	Pretreatment with dextran 70	Control group
Number of patients	85 (56 males, 29 females)	77 (54 males 23 females)
Mean catheterisation time (minutes)	40	43
Patients treated with anticoagulants	11	10
Patients with coronary heart disease	41	37

Table 2

Thromboembolic complications in two consecutive series of patients undergoing coronary angiography

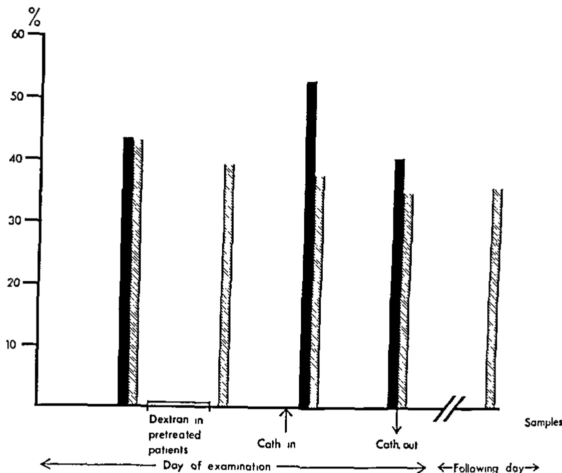
	Total number	Thromboembolism
Patients pretreated with dextran 70	85	0
Patients in the control group	77	6

Blood samples were obtained by venous puncture after brief stasis The first few milliliters of blood were discarded after which the blood was allowed to flow directly into siliconised glass tubes with a 10 ml mark and containing 1 ml of 3 8 % sodium citrate

The platelet adhesiveness was assessed with HELLEM s whole blood method (1960) The values were not corrected for changes in haematocrit (Hct) due to the infusion of dextran 70

The first blood sample was obtained immediately before and the second immediately after the termination of infusion of dextran 70 The third sample was collected 10 minutes after introduction of the catheter but before injection of the contrast medium and the fourth after withdrawal of the catheter A fifth sample was obtained twenty four hours after beginning the infusion Platelet counts and haematocrit values were obtained in twenty nine of the thirty six cases. The platelets were counted by the method of BJORKMAN (1959) and haematocrit was measured by the micro-method The values given in the tables are the means of double determinations

Statistical methods Comparisons between pairs of intra individual observations were made by analysing the means of paired differences by the student s t test A difference was considered significant if a calculated t value was more than $t_{0.95}$ $(n-1)$ where n is the number of differences Differences between proportions



Comparison of platelet adhesiveness (ordinate) in two series of patients undergoing coronary angiography with (striped bars) and without (black bars) pretreatment with dextran 70 For details of latter series see JACOBSSON (1969b)

were analysed by χ^2-tests A 5 % significance level was used ($p < 0.05$) Means are in the table denoted with $\bar{x}$ and standard deviations with S D

Results

Thromboembolic complications The number of thromboembolic complications in the group treated with dextran and in the control group is apparent from Table 2 In six of the seventy seven patients who were *not* pretreated, oscillography showed a reduction in the pulse rate for 2 hours after the examination, which is a sign of thromboembolism (JACOBSSON et coll 1969b) Subsequent angiography or operation demonstrated thromboembolism in five of these patients The sixth patient was a woman in poor general condition with decreased

Table 3

Platelet adhesiveness haematocrit and platelet counts in patients undergoing coronary angiography after treatment with dextran 70

	Before dextran infusion			After dextran infusion			After insertion of catheter			On withdrawal of catheter			Following day		
	$\bar{x}$	*n*	*SD*	$\bar{x}$	*n*	*SD*	$\bar{x}$	*n*	*SD*	$\bar{x}$	*n*	*SD*	$\bar{x}$	*n*	*SD*
Platelet adhesiveness	43 1	36	9 7	39 6	36	10 9	38 0	36	11 9	35 4	36	12 7	36 4	17	12 9
Haematocrit	42 4	29	4 3	39 8	29	3 9	39 0	29	4 0	40 1	29	3 4	42 3	11	5 2
Platelet count	285	29	71	279	30	60	278	29	57	273	30	49	253	11	39

pulsations only in the lower leg Since she showed no signs of ischaemia, no special treatment was given

In none of the eighty five pretreated patients were symptoms or signs of thromboembolism observed The difference was significant

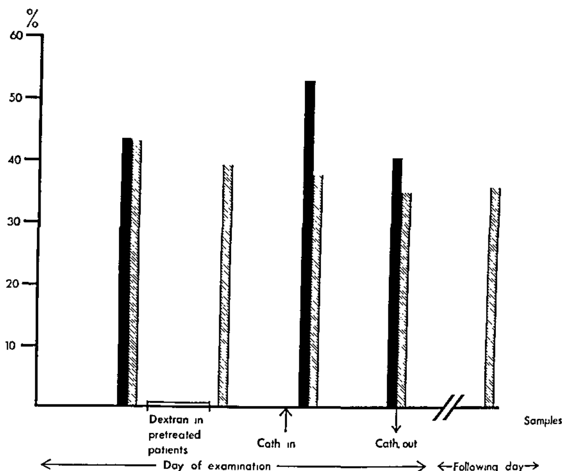
Platelet adhesiveness was originally the same in both groups (see Diagram) In the untreated group the adhesiveness increased after catheterisation (JACOBSSON 1969b) In the group pretreated with dextran 70 the adhesiveness decreased gradually The adhesiveness was lowest after the catheter had been withdrawn but there was still a decrease on the following day

The haematocrit fell significantly (Table 3) and was lowest after insertion of the catheter It aftervards increased and the day after the examination it had reached the original level The platelet count remained unchanged (Table 3)

Side effects of dextran No serious side effect of the dextran infusion was observed It seemed to us that haemostasis required a somewhat longer compression than usual Poor haemostasis is liable to result in pseudoaneurysm However four patients in the control group and one in the other group were subjected to operation because of this complication

Discussion

Thromboembolism occurred in 8 % of the untreated patients but in none of those pretreated with dextran 70 This cannot have been due to differences in age and sex distribution frequency of treatment with anticoagulants coronary disease or different examination techniques (Table 1) but most probably to the effect of dextran Dextran was found to decrease the platelet adhesiveness with a



Comparison of platelet adhesiveness (ordinate) in two series of patients undergoing coronary angiography with (striped bars) and without (black bars) pretreatment with dextran 70 For details of latter series see JACOBSSON (1969b)

were analysed by χ^2-tests A 5 % significance level was used ($p < 0.05$) Means are in the table denoted with $\bar{x}$ and standard deviations with S D

Results

Thromboembolic complications The number of thromboembolic complications in the group treated with dextran and in the control group is apparent from Table 2 In six of the seventy seven patients who were not pretreated, oscillography showed a reduction in the pulse rate for 2 hours after the examination, which is a sign of thromboembolism (JACOBSSON et coll 1969b) Subsequent angiography or operation demonstrated thromboembolism in five of these patients The sixth patient was a woman in poor general condition with decreased

Table 3

Platelet adhesiveness haematocrit and platelet counts in patients undergoing coronary angiography after treatment with dextran 70

	Before dextran nfus on			After dextran nfus on			After insertion of catheter			On withdrawal of catheter			Following day		
	$\bar{x}$	*n*	S D	$\bar{x}$	*n*	S D	$\bar{x}$	*n*	S D	$\bar{x}$	*n*	S D	$\bar{x}$	*n*	S D
Platelet adhesiveness	43 1	36	9 7	39 6	36	10 9	38 0	36	11 9	35 4	36	12 7	36 4	17	12 9
Haematocrit	42 4	29	4 3	39 8	29	3 9	39 0	29	4 0	40 1	29	3 4	42 3	11	5 2
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maximum occurring some hours after the termination of infusion, which is in agreement with results of other investigators (BYGDEMAN et coll 1966, CRONBERG et coll 1966, BENNET et coll 1968) Since no correction was made for changes in the haematocrit, some reduction of the adhesiveness might be accounted for by haematocrit changes But such changes did not correspond to those in platelet adhesiveness

JACOBSSON has demonstrated that thromboembolism following vascular catheterisation is caused by adhesion of platelets to the catheter It may therefore be concluded that dextran 70 decreases the frequency of thromboemboli following percutaneous arterial catheterisation by decreasing the platelet adhesiveness

The use of dextran 70 to lower the platelet adhesiveness has certain disadvantages It requires intravenous infusion of large volumes of fluid which may be hazardous in debilitated patients with heart disease In the present consecutive series of patients submitted to coronary angiography no patient showed any signs of overloading, however

It has also been found (CRONBERG et coll 1966) that dextran 70 may prolong the bleeding time Even if it does, this effect appears to be of less importance Another disadvantage of dextran 70 is that infusion takes such a long time that in practice there will only remain a relatively short time during the day for performing the catheterisation Still, it seems to us advisable that until a more suitable catheter or anti adhesive agent, has become available, dextran 70 should be administered to patients who are to undergo an examination requiring a long catheter, e g for coronary angiography The pretreatment seems on the other hand not to be necessary in abdominal angiography because of the much lower frequency of thromboembolism after such examinations (JACOBSSON & SCHLOSSMAN 1969a) We then prefer to use the thinnest possible catheters

SUMMARY

This investigation was made in an attempt to establish whether reduced platelet adhesiveness achieved by pre infusion of dextran 70 would lead to a reduction of the thrombo embolism that frequently follows percutaneous catheterisation for coronary angiography Thromboembolism occurred in 8 % of the patients examined without previous treatment but in none of the patients treated with dextran 70

ZUSAMMENFASSUNG

Diese Untersuchung wurde vorgenommen um festzustellen ob eine Reduktion der Thrombocytenadhasivitat die durch Prainjektion von Dextran 70 erreicht wurde zu einer Reduktion im Auftreten von Thromboembolism nach perkutaner Katheterisierung fur Koronarangiographie fuhren wurde Thromboembolien entstanden in 8 % der Patienten die ohne vorherige Behandlung untersucht wurden wahrend die nicht der Fall war in den Patienten die mit Dextran 70 vorbehandelt wurden

RÉSUMÉ

Ce travail expérimental a été entrepris pour essayer d'établir si la diminution de l'adhésivité des plaquettes obtenues par perfusion préalable de dextran 70 diminue le risque de thrombo-embolie qui suit fréquemment le cathétérisme percutané pour angiographie coronaire. Des thrombo-embolies se sont produites chez 8 % des sujets examinés sans traitement préalable mais aucune n'est survenue chez les sujets traités par le dextran 70.

REFERENCES

AHLBERG Å NYLANDER G ROBERTSON B et coll Dextran in prophylaxis of thrombosis in fractures of the hip Acta chir scand (1968) Suppl. No 387 p 81

ATIK M Platelet adhesiveness and thromboembolism Paper read at the International Conference of Microcirculation at Gothenburg Sweden 1968

BENNET P N Postoperative changes in platelet adhesiveness. J clin. Path 20 (1967) 708

— DHALL D P and MATHESON N A Effect of dextran 70 infusion on platelet adhesiveness after operation Brit J Surg 55 (1968) 289

BJORKMAN S E A new method for enumeration of platelets. Acta haemat 22 (1959) 377

BYGDEMAN S and ELIASSON R Effect of dextrans on platelet adhesiveness and aggregation Scand J clin Lab Invest 20 (1967) 17

— — and GULLBRING B Effect of dextran infusions on ADP induced platelet adhesiveness and platelet spreading capacity Thrombos Diathes haemorrh (Stuttg) 15 (1966) 345

CRONBERG S ROBERTSON B NILSSON I M and NIHLEN J E. Suppressive effect of dextran on platelet adhesiveness Thrombos Diathes haemorrh (Stuttg) 16 (1966) 384

HELLEM A J The adhesiveness of human blood platelets in vitro Scand J clin Lab Invest (1960) Suppl No 51

HUGUES J Sticking of platelets to perivascular connective tissue Thrombos Diathes haemorrh (Stuttg) 8 (1962) 241

JACOBSSON B (a) Platelet adhesion and aggregation following contact between blood and vascular catheters To be published in Scand J Haemat

— (b) Effect of vascular catheterisation on platelet adhesiveness To be published in Europ Surg Res

— and SCHLOSSMAN D (a) Thromboembolism of leg following percutaneous catheterisation of femoral artery for angiography Predisposing factors Acta radiol Diagnosis 8 (1969) 109

— — (b) Angiographic investigation of formation of thrombi on vascular catheters To be published in Radiology

— BERGENTZ S E and LJUNGQVIST U (a) Platelet adhesion and thrombus formation on vascular catheters in dogs Acta radiol Diagnosis 8 (1969) 221

— PALLIN S and SCHLOSSMAN D (b) Thromboembolism of leg following percutaneous catheterisation of femoral artery for angiography Symptoms and signs Acta radiol Diagnosis 8 (1968) 97

JOHNSON S R BYGDEMAN S and ELIASSON R Effect of dextran on postoperative thrombosis Acta chir scand (1968) Suppl No 387 p 80

MUSTARD J F GLYNN M F NISHIZAWA E E and PACKHAM M A Platelet surface interactions relationship to thrombosis and hemostasis. Fed Proc 26 (1967) 106

OWREN P A The haemostatic plug Thrombos Diathes haemorrh (Stuttg) (1964) Suppl No 13 p 325

PALLIN S Coronary angiography A technical anatomic and clinical study Acta radiol (1964) Suppl No 233

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CEREBRAL CIRCULATION TIME AND CEREBRAL BLOOD FLOW

Comparison of angiography and the ^{133}Xe technique

by

S Cronqvist and T Greitz

Cerebral circulation in man has been investigated mainly by angiography and by determination of the cerebral blood flow Cerebral angiography, although primarily introduced for morphologic studies, has proved to be of great value in the study of the physiologic features of the circulation Serial angiography makes it possible to demonstrate the transportation of contrast media through the vessels of the brain and thus to determine the mean circulation time (Greitz 1956) The cerebral circulation time (CCT) reflects important physiologic aspects of the circulation These aspects do not seem yet to have been properly utilized since determination of the cerebral circulation time appears to have been restricted mainly to the differential diagnosis of neoplasms

Introduction of the isotope clearance method, permitting quantitative measurement of the cerebral blood flow (CBF) expressed in ml/100 g brain tissue/min has opened up new possibilities for studying the cerebral circulation and has stimulated further research activity in this field

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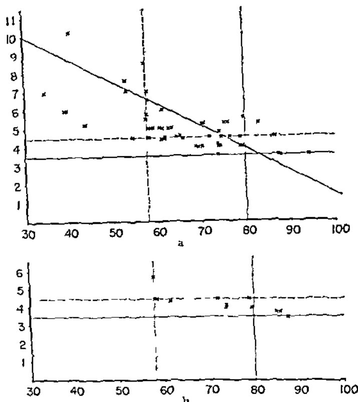


Fig 1 Correlation between cerebral circulation time (CCT) (ordinate) as determined by angiography and the fast component of the cerebral blood flow (CBF) (abscissa) a) All cases parietal veins. Vertical lines indicate mean (full line) and 2 S D (dotted line) of normal values for cerebral blood flow Horizontal lines represent corresponding values for normal circulation time Oblique line indicates regression of CBF on CCT CBF = 110 − 8 CCT b) Cases with varying diagnoses and angiography without focal changes Eleven cases had a prolonged circulation time and only one had abnormal cerebral blood flow

It cannot be assumed that the velocity expressed as the mean circulation time can be directly correlated to flow expressed as volume per minute A comparison was therefore made between the circulation times determined by angiography and by quantitative blood flow measurements in order to find out if any correlation exists

Methods Serial angiography was performed in all cases after the injection of 5 ml Urografin 60 % into the internal carotid artery The series consisted of a

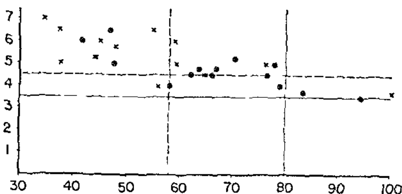


Fig 2 Correlation between cerebral circulation time (CCT) (ordinate) as determined by angiography and the fast component of the cerebral blood flow (CBF) (abscissa) Cases of cerebrovascular lesions The cases marked with crosses in circles had angiographic signs of a focal lesion

total of 20 films obtained in approximately 15 seconds, two films per second were exposed during the first six seconds The mean circulation time was taken as the time interval between the maximal filling of the carotid siphon and maximal filling of the parietal veins (GREITZ)

The mean circulation time is approximately 3 5 ± 0 5 seconds in normal subjects (GREITZ 1968) Some cases with parietal lesions were also included in the material Disturbances in the parietal venous filling may result in a false evaluation of the mean circulation time The mean value of the time interval between maximal filling of the carotid siphon and maximal filling of veins in several regions was therefore also calculated The frontal parietal occipital middle cerebral and internal cerebral veins were used

The cerebral blood flow was studied by the isotope clearance method (INGVAR & LASSEN 1962, LASSEN et coll 1963) By using multiple extracranially localized detectors the method permits a simultaneous determination of the blood flow in different regions Two types of flow, a fast and a slow, are encountered The fast flow values will be emphasized in this paper normally these have been found to be about 80 ± 11 ml 100 g brain tissue/min (INGVAR et coll 1965) No correction for variations in arterial carbon dioxide tension were made

Material A total of 115 angiograms and blood flow measurements were obtained in 94 cases, thirty of which were examined in Stockholm and sixty four in Lund In the latter cases, 4 to 8 extracranially localized detectors were used and both the hemispheric and regional blood flow were determined

The cases fell into three groups according to the clinical diagnosis Twenty seven cases without evidence of cerebrovascular disease had no clinical signs indicating a focal lesion, and the angiogram was normal in each A second group

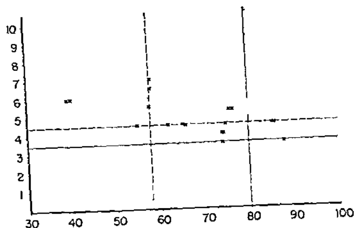


Fig 3 Correlation between CCT (ordinate) and CBF (abscissa) in cases of subarachnoid haemorrhage Prolonged circulation time was more often observed than abnormal flow values.

included thirty six cases with signs of focal cerebrovascular lesions The third group was formed of thirty-one cases with the clinical diagnosis of subarachnoid haemorrhage with and without focal signs Repeat studies were made in some of the cases in the latter group and a total of forty four determinations of the cerebral circulation time and cerebral blood flow were performed

Results

The results of all studies are presented in Fig 1a The circulation times as determined by angiography are plotted against fast flow values of cerebral blood flow Full lines indicate normal mean values broken lines mean values ± 2 S D The majority of values lean towards the area indicating decreased flow and prolonged circulation time respectively Although there was a marked scatter with low flow values and prolonged circulation times, a definite correlation existed between the results of the two methods Assuming a linear relationship the regression of cerebral blood flow on cerebral circulation time was calculated for the entire material and proved to be approximately CBF = 110 − 8 CCT the regression of CCT on CBF being CCT = 8 – 0 05 CBF

The cases are grouped according to their clinical diagnoses in Figs 1b and 2 and in Fig 3 The regression of CBF on CCT was about 125 – 12 CCT the residual standard deviation being 7 in the 27 cases without focal clinical signs and without focal changes at angiography The regression of CCT on CBF was 8 3 – 0 06 CBF and the corresponding residual S D was 0 5 Only two cases had flow values below the lower normal limit (mean value ± 2 S D) in this

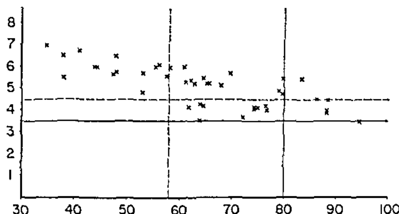


Fig 1 All three types of cases The cerebral circulation time was calculated as the mean of the regional circulation times Correlation is improved in comparison with fig 1 a

group (Fig 1b) This is opposed to the finding that about eleven out of the twenty seven cases were found to have a pathologically prolonged circulation time

The variables also presented a strong correlation in the other two groups of cases (Figs 2 and 3) but with a significantly greater residual standard deviation, this was 15 6 for cases with cerebrovascular lesions and 12 5 for cases with subarachnoid haemorrhage The differences between these residual standard deviations were, however, not significant, nor were there any significant differences between these two groups with regard to the regression of CBF on CCT or the regression of CCT on CBF It therefore seemed justified from a statistical point of view to treat these two subgroups as an entity For the two groups represented in Figs 2 and 3 the regression CBF on CCT was CBF = 103 - 7 7 CCT, with a residual S D of 14 The inclination of this regression line differed significantly from that of the first subgroup as represented in Fig 1b, evidently due to the fact that the relationship with lower flow values is non linear The existence of a non linear relationship is also made obvious by the fact that the correlation between CCT and CBF as presented here should mean that the flow becomes zero with a circulation time of 10 to 15 seconds Indisputable clinical experience with angiography proves that this is not the case

No differences between cases with and those without focal angiographic changes due to a cerebral vascular lesion were observed (Fig 2) Values from cases with either of these types of angiographic findings occurred within as well as outside, the normal limits for CBF and CCT The CBF was below normal limits in fifteen out of thirty six cases belonging to this group, while a pathologically prolonged CCT was observed in no less than twenty seven cases

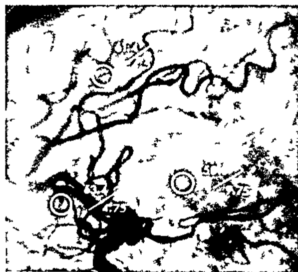


Fig 5 Thrombosis of middle cerebral artery Regional flow decreased and local circulation time prolonged in the temporal region

Cases with subarachnoid haemorrhage (Fig 3) had a marked scatter of values when the CBF was pathologically low (16 determinations) A prolonged circulation time was noted in twelve of the instances in which CBF was normal Only in one of the sixteen instances with abnormally low flow was a normal value for CCT registered

In twenty six of 44 instances in which angiography was made in cases with subarachnoid haemorrhage and in thirty one of the cases with cerebrovascular lesion the CCT was also taken as the mean value of the time interval between maximal filling of the carotid siphon and maximal filling of veins in different regions The mean CCT determined in this way was correlated to the hemispheric fast CBF values The correlation between the two variables was stronger and the residual standard deviation was smaller than when CCT was determined from parietal veins only (Figs 1a and 4)

Discussion

Previous work (Greitz 1956 Greitz & Syk 1968) has indicated that the standard error of the observer in evaluating CCT is low (0 19 seconds) when the determination is based upon serial films of the same number and of the same frequency as used here The fact that CCT in this series was determined by

different neuroradiologists should therefore not invalidate the results obtained GREITZ & SYK (1968) have further claimed that although maximal filling of veins may seem more difficult to define with prolonged circulation time, this does not significantly influence the error of method

Both the circulation time and the cerebral blood flow have been proven to be influenced in the same direction by variations of the arterial carbon dioxide tension The exact increase or decrease expressed in seconds and in ml/100 g/min is unrecorded even in the normal brain and naturally may be different in cases of cerebral disorders Because of this, no correction for $apCO_2$ has been made in the present series

Although a correlation between CCT and CBF existed for the whole series, the strongest correlation and the smallest residual standard deviation were noted in the group in which angiography was without focal changes and in which the clinical signs did not predict a focal lesion It is however noteworthy that even in these non focal cases a pathologically prolonged circulation time occurred in eleven out of twenty seven cases Hence, by determining the cerebral circulation time, it was possible to reveal disturbances in the cerebral circulation in cases in which angiography was normal from an anatomical point of view Among cases with clinical signs of focal vascular lesions, a prolonged CCT was noted in twenty seven of the thirty seven determinations made, while the CBF was found to be abnormal in only sixteen instances

Similar observations, i e that the CCT was more often abnormal than the CBF, were made also in cases with subarachnoid bleeding The correlation appeared to be weaker in those cases in which there were low flow values and prolonged circulation times than in the other two kinds of cases described The discrepancy could be due to the presence of various degrees of spasm and also to the varying localization of the spasm in different aneurysms (CRONQVIST & KAGSTROM) That focal changes in the circulatory pattern really are responsible is evident from the fact that when the mean CCT calculation was based upon the maximal filling of several regional veins and not upon filling of the parietal veins only, a stronger correlation was evident in this range of measurements Additional proof was also obtained from the fact that in cases with a known well defined vascular lesion the correlation between the CBF and mean CCT, calculated in the manner described above, was stronger than when the mean CCT determination was based upon the filling of only the parietal veins It should be stressed that all the correlations presented are relevant only to the types of cases examined in this work, i e essentially normal cases and those with cerebrovascular lesions Haemodynamic disturbances that produce a relationship between the CCT and CBF, different from that in the present material, may occur with other types of lesions

Focal disturbances in the venous filling have earlier been described in a variety of cerebral lesions apparently corresponding to regional changes in the CBF (CRONQVIST 1968, CRONQVIST & LAROCHE 1967). Since a correlation exists between the mean CCT and the hemispheric blood flow, a correlation between the regional values for the CBF and regional CCT may also be expected (see Fig. 5).

Conclusions

The investigation has demonstrated a correlation between the cerebral circulation time (CCT) and cerebral blood flow (CBF). The regression of the CBF (fast flow) on the CCT was significantly different in cases with essentially normal flow values and in those with cerebrovascular disease and low flow values in that the changes in the CBF tended to be less marked with long circulation times. This suggests that the correlation between CCT and CBF is in fact non-linear. This correlation was strongest in cases without focal angiographic changes and when the determination of CCT was taken as the mean time interval between the maximal filling of the carotid siphon and maximal filling of veins in several regions.

Circulation time, as determined by angiography, is an easily obtained indicator of circulatory disturbances and appears to be more sensitive than CBF, at least in certain types of haemodynamic disturbances. It would thus appear that determination of the CCT must be a routine measure at cerebral angiograpny. This is especially important when the angiographic findings appear normal from a morphologic standpoint.

Acknowledgement

This work was supported by grants from the Swedish Research Council and the Swedish Cancer Society.

SUMMARY

The mean cerebral circulation time was studied with angiography of the carotid artery and the cerebral blood flow determined with the xenon 133 clearance method in three groups of cases. The first group was without clinical or angiographic signs of an intracerebral focal lesion, the second had clinical evidence of a cerebrovascular lesion and the third group had subarachnoid haemorrhage. A significant correlation between the circulation time and cerebral blood flow existed in all three groups.

ZUSAMMENFASSUNG

Die durchschnittliche cerebrale Blutumlaufzeit wurde mittels Karotisangiographie und die cerebrale Durchblutung mittels der Xenon 133 Ausscheidungsmethode in drei verschiedenen Gruppen von Fällen studiert. In der ersten Gruppe war keine klinisch oder angiographisch

nachweisbare Herderkrankung des Gehirns vorhanden, klinisch lag in der zweiten Gruppe cerebrovaskulare Erkrankung vor und die dritte Gruppe hatte subarachnoidale Blutung Eine signifikante Korrelation zwischen der Umlaufzeit und der cerebralen Durchblutung konnte in allen drei Gruppen festgelegt werden

RÉSUMÉ

Le temps de circulation cérébrale moyen a éte etudié par angiographie carotidienne et le debit cerébral a eté mesure par la methode de clearance du xenon 133 dans trois groupes de cas Le premier groupe n avait pas de signe clinique ou angiographique de lesion focale intracerebrale le second avait des signes cliniques de lesion vasculaire cérébrale et le troisieme avait une hemorragie sous arachnoidienne Les auteurs ont trouvé une correlation significative entre le temps de la circulation et le debit cérebral dans ces trois groupes

REFERENCES

CRONQVIST S Transitory hyperemia in focal cerebral ischemic lesion *In* Proceedings of the research group on cerebral circulation Salzburg 1966 Charles C Thomas New York 1968

— and KAGSTROM E Regional cerebral blood flow in subarachnoid haemorrhage To be published in Acta radiol Diagnosis

— and LAROCHE F Transitory hyperaemia in focal cerebral vascular lesions studied by angiography and regional cerebral blood flow measurements Brit J Radiol 40 (1967) 270

GREITZ T A radiologic study of brain circulation by rapid serial angiography Acta radiol (1956) Suppl No 140

— Normal cerebral circulation time as determined by carotid angiography with sodium and methylglucamine diatrizoate (Urografin) Acta radiol Diagnosis 7 (1968) 331

— and SVK B Densitometric and visual evaluation of the circulation time in carotid angio graphy A methodologic study Acta radiol Diagnosis 7 (1968) 145

INGVAR D H and LASSEN N A Regional blood flow of the cerebral cortex determined by krypton Acta physiol scand 54 (1962) 325

— CRONQVIST S EKBERG R et coll Normal values of regional cerebral blood flow in man including flow and weight estimates of grey and white matter Acta neurol scand (1965) Suppl No 14 p 72

LASSEN N A HØEDT RASMUSSEN K SORENSEN S C et coll Regional cerebral blood flow in man determined by a radioactive inert gas Neurology 13 (1963) 719

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ANGIOGRAPHIC DEMONSTRATION OF COLLATERALS TO THE CORONARY ARTERIES IN PATIENTS WITH ANGINA PECTORIS

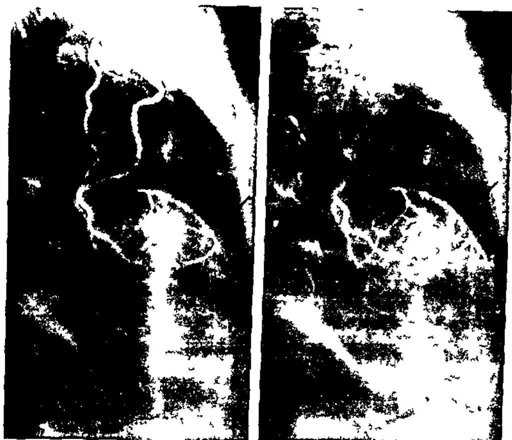
by

LARS BJORK

Intercoronary and extracardiac anastomoses to the coronary arteries may be demonstrated by various methods of coronary angiography (SONES et coll. 1959, PAULIN 1964, ARVIDSSON & MOBERG 1966, BJORK 1966 and others). Successful results of operative procedures to increase the vascularization of the myocardium may also be documented by angiography (see accompanying illustration). It must be emphasized however that it is essentially the anatomy of the arteries that is demonstrated by these angiographic methods and it is well known from vascular studies using peripheral and renal angiography that it is difficult to correlate the anatomical findings at angiography with disturbances of function. It is only to be expected that the same would apply to the myocardium and the anatomy of the coronary arteries as seen at coronary angiography.

To investigate these factors, a study was made of 65 patients referred for surgical treatment of angina pectoris. Electrocardiograms with standard and various precordial leads were obtained in all these patients, and the physical work capacity was determined by means of a bicycle ergometer (HALLEN 1964).

Submitted for publication 5 September 1968



Roentgenograms obtained 26 months after implantation of the internal mammary artery into the myocardium patent artery (→→) filling the anterior descending branch of the left coronary artery (⟶) through collaterals

Coronary angiography as well as left ventricular cine angiography was performed in all the patients The findings at coronary angiography were divided in five groups, classified as follows

0 = normal coronary arteries

1 = narrowing of the lumen in at least one place but less than 50 % of the diameter of that artery

2 = narrowing of the lumen in at least one place by more than 50 % of the diameter but no delay in filling of the arterial branches distal to the obstruction

3 = the same as (2) but with delayed filling distal to the obstruction

4 = total occlusion of the artery

The presence of intercoronary, homocoronary and extracardiac anastomoses was noted The anastomoses were considered functionally important when there was good contrast filling distal to the occlusion in an artery

Table 1

Correlation of the degree of coronary arteriosclerosis in the most affected two major arteries, presence of collaterals to the coronary arteries and the physical work capacity

Degree of arteriosclerosis classified according to groups defined on p. 306	Presence or non-existence of collaterals	Maximal work capacity kpm/minute			
		250	250—499	500—749	750—
4+4 4+3	+	5	—	—	—
	—	2	3	1	—
4+3 or 2 3+3 3+3 or 2	+	3	7	6	1
	—	4	7	4	—

*Plus sign indicates filling of an artery distal to the stenosis through collaterals, minus sign that no collaterals were visible in the coronary angiograms.

Table 2

Correlation of the degree of coronary arteriosclerosis in the two most affected major coronary arteries, presence of collaterals and the findings at left ventricular angiocardiography

Degree of arteriosclerosis classified according to groups defined p. 306	Presence or non-existence of collaterals	Findings at left ventricular angiocardiography							
		End diastolic volume			End systolic volume			Dysfunction in wall	
		0	+	++	0	+	++	0	+
4+4 4+3	+	3	2	—	1	2	2	1	4
	—	3	2	1	2	2	2	3	3
4+2 4+1 3+3 3+2 3+1	+	14	2	1	5	10	2	6	11
	—	10	5	—	6	7	2	7	8

Plus sign indicates filling of an artery distal to the stenosis through collaterals, minus sign that no collaterals were visible in the coronary angiograms. Designations for left ventricular volumes: 0 normal, + moderately increased, ++ markedly increased.

Correlation between the degree of coronary artery sclerosis, collaterals to the coronary arteries and physical work capacity may be observed in Table 1. There is no significant difference in physical work capacity between patients with and without good collaterals as demonstrated by coronary angiography.

The demonstration of collaterals was not correlated to the left ventricular *volumes or to the function* (*Table 2*). Increased left ventricular end diastolic and end systolic volumes were equally frequent in patients with as in patients without good collaterals. Local dysfunction in the left ventricular wall, indicating a scar from previous infarction, occurred with equal frequency in patients with and without good collaterals to the occluded coronary arteries.

Another series of 70 patients, surgically treated for angina pectoris according to a combination of Beck's and Vineberg's principles, were studied six months to three years after the operation. Angiography of the implanted internal mammary artery revealed patency of the artery, like the one shown in the present roentgenograms, in 46 % of the patients. The degree of subjective and objective improvements was similar, however, whether the internal mammary artery was patent or not (BJORK et coll. 1968).

Conclusion

The angiographic demonstration of collaterals to the coronary arteries is of little clinical significance since it is no indication of the physical work capacity of the patient or of the functional state of the myocardium. This is in agreement with the findings of BAROLDI (1966) whose post mortem injection studies of human hearts with coronary artery disease produced no definite correlation *between the number of collateral vessels and the extent of damage to the myo*cardium. MOBERG (1968) reported that extracardiac anastomoses to the coronary arteries increased in number and size with age and the degree of coronary stenosis. These anastomoses had a true anastomotic function but their importance for the myocardial blood supply could not be evaluated. At the moment the angiographic method is too insensitive to be utilized for studying the coronary collateral circulation. A detailed analysis of full size high definition coronary angiograms, *permitting a demonstration of minute vascular branches* and the calculation of the number of these branches per volume heart muscle, could possibly increase the value of the method.

SUMMARY

Normal and surgically created collaterals to the coronary arteries were demonstrated by angiography in patients with angina pectoris. No correlation could be established between the presence of collaterals and the physical work capacity of the patient, the functional state of the myocardium or the degree of improvement following operation

ZUSAMMENFASSUNG

Normale und chirurgisch hergestellte Kollateralgefasse zu den Koronararterien wurden mittels Angiographie bei Patienten mit Angina pectoris dargestellt Keine Korrelation zwischen der Existenz von Kollateralgefassen und der Arbeitsfahigkeit der Funktionsfahigkeit des Myokardiums und dem Grad der postoperativen Besserung der Patienten konnte festgestellt werden

RÉSUMÉ

L angiographie a permis de mettre en evidence des collaterales des arteres coronaires les unes normales les autres creees chirurgicalement chez des malades atteints d angine de poitrine La presence des collaterales n est pas en rapport avec l aptitude du malade au travail physique l etat fonctionnel du myocarde ou le degre d amelioration qui a suivi l operation

REFERENCES

ARVIDSSON H and MOBERG A Extracardiac anastomoses to the myocardium Preliminary report of angiocardiographic and anatomic studies Acta radiol Diagnosis 4 (1966) 385

BAROLDI G Myocardial infarct and sudden coronary heart death in relation to coronary occlusion and collateral circulation Amer Heart J 71 (1966) 826

BJORK L Angiographic demonstration of extracardial anastomoses to the coronary arteries Radiology 87 (1966) 274

— CULLHED I HALLEN A and STROM G Result of internal mammary artery implantation in patients with angina pectoris Scand J thorac cardiovasc Surg 2 (1968) 1

HALLEN A Angina pectoris A clinical study with special reference to surgical treatment Acta chir scand (1964) Suppl No 323

MOBERG A Anastomoses between extracardiac vessels and coronary arteries Acta med scand (1968) Suppl No 485

PAULIN S Coronary angiography Acta radiol (1964) Suppl No 233

SONES F M SHIREY E K PROUDFIT W L and WESTCOTT R N Cinecoronary arteriography *In* Proc 32nd Sci Sessions Amer Heart Ass 1959

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ISOTOPE SCANNING OF SPINAL CORD CYSTS

by

T Greitz and A B Ellertsson

It has been possible to diagnose cystic lesions in the cervical part of the medulla by examining the patient with Pantopaque myelography in supine position and gas myelography in sitting position (Conway 1961, 1967, Heinz et coll 1966) Similarly, volume variations suggesting the presence of cysts in the cervical spinal cord have been demonstrated by gas myelography and encephalography (Wickbom & Hanafee 1963, Gardner 1965) The technique for lumbar gas myelography, recently introduced, has now made it possible to diagnose cystic changes in all parts of the spinal cord (Westberg 1965, 1966) Long flaccid cysts can be distinguished from other types of cystic intramedullary lesions (Westberg 1966) The demonstration of a flaccid cyst by gas myelography is sufficient justification for making a diagnosis of syringomyelia with complete certainty On the other hand, this roentgen finding is not indispensible to the diagnosis of syringomyelia, since the cyst may disappear and leave a spinal cord atrophy (Ellertsson 1969a) Most cases of syringomyelia can be distinguished from other types of intramedullary cyst by their clinical manifestations, by findings in the examination of the cerebrospinal fluid and the cyst fluid, and by roentgen observations (Ellertsson 1968, 1969b) Communication between the cyst and the cerebrospinal fluid space occurs in syringomyelia but not in other types of intramedullary cyst (Ellertsson & Greitz 1969)

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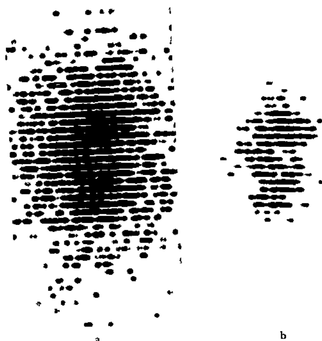


Fig 1 Isotope myelocystography in a case of partly fluctuating spinal cord cyst a) Scanning without discrimination b) Photograph discrimination Extension of cyst only in the midportion of the expanding lesion which was fluctuating at both ends (cf fig 2) Punctures above and below the cyst revealed additional cysts

A study of such a communication has been made by isotope scanning after percutaneous puncture of the cyst by the Westberg method and direct injection of RIHSA into the cyst (ELLERTSSON & GREITZ) It seemed of interest to investigate whether this method which has been called isotope myelocystography could be used as an alternative for cystography with air in assessing the size of the cyst It is often difficult particularly when the cyst is not flaccid to determine by gas myelography alone how much of the expanding lesion is cystic and how much is solid

Isotope myelography (BAUER & YUHL 1953, 1957 PERRYMAN et coll 1958 BELL 1962 HUBNER & BROWN 1965 WACKENHEIM 1965 DIETZ et coll 1966) has been introduced in recent years for the diagnosis of expanding lesions in the spine We have used this method in attempts to diagnose intramedullary cystic processes and to distinguish if possible between different types of spinal cord cysts



Fig. 2. Gas myelography in the same case as in fig. 1. Expanding lesion from Th 8 to upper border of Th 12 (large arrow). Small fluctuations induced by variation in the patient's position both at the upper (a and b) and lower (c and d) end of the lesion (small arrows).

Material and Methods. Six cases of flaccid cyst (considerable fluctuations of the entire spinal cord cyst) and three cases of partially fluctuating cyst (fluctuations in part of the cyst) were studied. The alterations in the shape of the spinal cord were diagnosed by gas myelography (WESTBERG 1966).

RIHSA in physiologic salt solution containing 10 to 12 mg albumin per mCi ^{131}I was used both for isotope myelocystography and isotope myelography. All the scintigrams were obtained with a Picker Magnascanner with a 3 by 2 inch large NaI (Tl) scintillation crystal and a 19 hole focussing collimator with a focus distance of about 76 mm. All recordings were made both with the teledeltos system and with photorecording. The scanning speed was as a rule 24 cm/min and the line space 6 mm; the spectrometer was set to record energies of from 270 to 455 keV.

Isotope myelocystography. In five cases, four of which with flaccid cysts, 60 to 100 μCi RIHSA in 0.5 to 2 ml physiologic saline were injected into the cyst and scanning was performed over the back with the patient in prone position. The radiation dose to the cyst wall, disregarding the biologic elimination, was calculated as not exceeding 250 rad in a cyst with a volume of 20 to 25 ml.



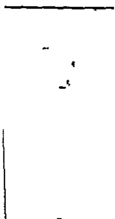
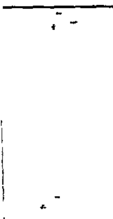



Fig 3 | Fig 4a | Fig 4b | Fig 4c

Fig 3 Isotope myelocystography in a case of flaccid spinal cord cyst extending from C 1 to Th 6 as seen at gas myelography The distribution of the isotope within the cyst is somewhat irregular

Fig 4 Myelocystography in a case of flaccid cyst performed with 100 μCi RIHSA at 8 (a) 24 (b) and 48 (c) hours after injection Relatively slight activity over the cyst in the 48-hour scan horizontal line indicates the level of the external auditory meatus

Isotope myelography This was used in four cases two with flaccid and two with a partially fluctuating cyst (BAUER & YUHL 1953 1957 PERRYMAN et coll 1958 BELL 1962 HUBNER & BROWN 1965 WACKENHEIM 1965) An amount of 1 μCi RIHSA per kg bodyweight was injected in the lumbar region and scanning was performed over the whole spine and when there was free passage in the cranial direction over the head as well (DI CHIRO et coll 1964 DIETZ et coll 1966 BANNISTER et coll 1967) An amount of 100 μCi RIHSA injected intrathecally in the lumbar region gives an average dose of beta radiation corresponding to 2 7 rad over the surface of the spinal cord (HILDITCH 1968)

Results

Isotope myelocystography The size of the cyst could be studied by direct injection of RIHSA into the cysts and immediate scanning (Figs 1 2 and 3) Its image was enlarged owing to the use of the coarse collimator Successive



Fig 5 Myelocystography in a partially fluctuating cyst containing 20 ml of fluid performed at 1 (a) 24 (b) 48 (c) and 72 (d) hours after injection of 100 μCi RIHSA At 72 hours there is still activity in the cyst

discrimination of the photoscintigrams, either by photocopying (DEWEY et coll 1962) or electronically with closed circuit television (BENDER & BLAU 1959), enabled increasingly small areas with a rising level of activity to be delineated A high uptake was thus demonstrated centrally within an area whose width corresponded to the probable width of the cyst, which cannot be expected to exceed the diameter of the spinal canal The length of the cyst was therefore measured in connection with this discrimination and the figure obtained was assumed to correspond to a maximum measurement The error at a length and width estimation of this kind probably does not exceed 20 % (MYHILL et coll 1965)

The activity was slightly unevenly distributed in all the cysts examined and the distribution was the same in repeated scans In two cases, one of a flaccid cyst and one of a partially fluctuating cyst, scanning was continued as long as activity exceeding the background activity was present in the cyst After three days only traces of activity remained in the flaccid cyst (Fig 4) while the partially fluctuating cyst, which contained 20 ml fluid, in other words as much as an ordinary flaccid cyst, after this period still exhibited a relatively large residue of activity (Fig 5) At gas myelography the latter case had been found to have an expanding process extending from Th 8 to Th 11, with fluctuations both at the upper



Fig 6 Isotope myelocystography before (a) and during gas myelography with head lowered (b) The caudal portion of the cyst has collapsed and its upper portion appears slightly broader after replacement of the cerebrospinal fluid with gas

and lower poles (Fig 2) After puncture of the upper end a small cyst containing a few milliliters of cyst fluid was found At RIHSA myelography after renewed puncture approximately in the middle of the lesion the punctured cyst was seen to embrace Th 9 to Th 10 (Fig 1) Another puncture lower down revealed still another cyst

In two cases of flaccid cyst (syringomyelia) scans of the cyst performed before and after the cerebrospinal fluid had been replaced by air as in gas myelography revealed that the caudal part of the lesion had collapsed (Fig 6) Variations in shape due to change in patient position occurred only under similar conditions i e when the cyst was surrounded by gas.

Isotope myelography In two cases of flaccid cyst RIHSA injected in the lumbar region circulated upwards at a normal rate and had reached the cisterns after a few hours and the convexity after 24 hours Although most of the tracer had left the basal cisterns by that time activity was recorded cervically at the site of the spinal canal simultaneously with a maximum at the convexity This uptake could have been in the cyst and was especially noticeable in one of the cases (Fig 7) in which the cyst was punctured two hours after the injection and then

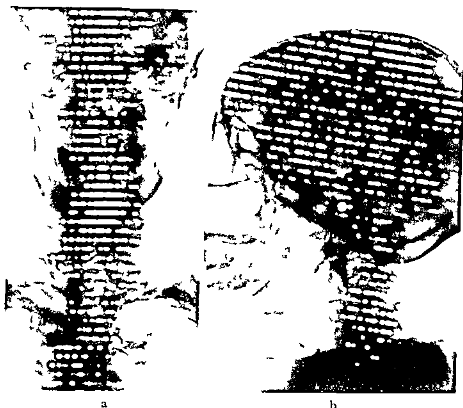


Fig 7 Isotope myelography in a case of flaccid cyst At 24 hours the isotope has reached the convexity (b) but activity still remains in the cervical area in both scintigrams probably in a communicating spinal cord cyst

contained radioactive cyst fluid In the other case, which also had persisting cervical activity despite an otherwise normal cerebrospinal fluid circulation, the cyst was punctured after 24 hours and at that time contained RIHSA The two cases of partially fluctuating cyst proved at isotope myelography to have an obstruction to the free circulation of the cerebrospinal fluid and no activity over the head was noted There was almost total block (Fig 8) at a location corresponding to the lower border of the lesion seen at gas myelography

Discussion and Conclusions

If volume variations in the spinal cord are demonstrated in connection with a change in the patient s position during gas myelography, this may be considered evidence of the presence of a cystic lesion It may be stressed that the diagnosis of spinal cord cysts was confirmed by percutaneous puncture *in all the nineteen* cases in which it had been made at gas myelography Fluctuations observed at

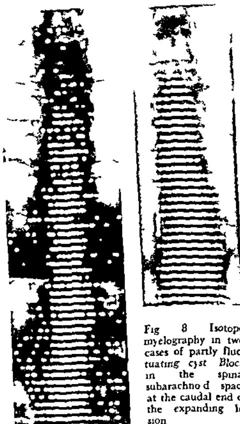


Fig 8 Isotope myelography in two cases of partly fluctuating cyst Block in the spinal subarachnoid space at the caudal end of the expanding lesion

gas myelography are sometimes inconsiderable and present only in a small part of the lesion this may cause difficulties in judging the size of the cyst Isotope myelocystography after percutaneous cyst puncture may then be used as an alternative to cystography with air in order to ascertain how much of the lesion is cystic and how much is solid

Evacuation of a cystic tumor in connection with a puncture has a favourable effect if the cyst is so large that it involves several segments or the greater part of the lesion (ELLERTSSON 1969b) Laminectomy, and possibly radiation therapy may perhaps be considered for the solid part As to flaccid cysts the extent of the lesion can be established with a high degree of certainty by gas myelography alone Myelocystography in these cases is sometimes useful for establishing if there is a communication with the cerebrospinal fluid space (ELLERTSSON & GREITZ) Furthermore it may be possible to draw conclusions concerning the

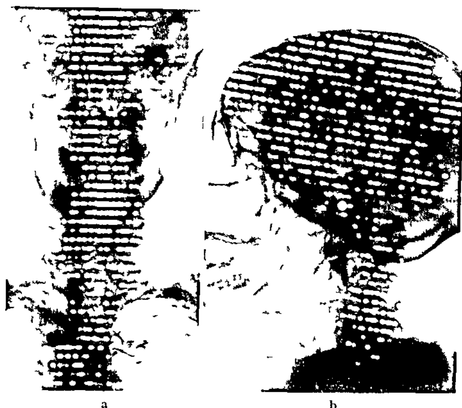


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RÉSUMÉ

Les auteurs ont examiné neuf malades atteints de kyste de la moelle épinière par kystographie médullaire isotopique par injection directe après ponction percutanée et par myélographie isotopique après injection sous arachnoidienne lombaire de RIHSA (serum albumine humaine marqué a l'iode radio-active) Ils examinent l'interet de ces methodes pour le diagnostic pour le diagnostic differentiel et pour preciser les dimensions du kyste

REFERENCES

BANNISTER R GILFORD E and KOCEN R Isotope encephalography in the diagnosis of dementia due to communicating hydrocephalus Lancet 1967 III p 1014

BAUER F K and YUHL E T Myelography by means of I^{131} The myeloscintigram Neurology 3 (1953) 341

— — Radioisotope myelography Int J appl Radiat 2 (1957) 52

BELL R L Automatic contour myelography in infants J nucl Med 3 (1962) 288

BENDER M A and BLAU M Versatile high contrast photoscanner for localization of human tumors with radioisotopes Int J appl Radiat 4 (1959) 154

CONWAY L W Radiographic studies of syringomyelia The hydrodynamics of the syrinx in relation to therapy Trans Amer neurol Ass 86 (1961) 205

— Hydrodynamic studies in syringomyelia J Neurosurg 27 (1967) 501

DEWEY W C HEIDELBERG J C and MOORE F B Use of photocopying process for erasing background of photoscans and accentuating small differences in optical density J nucl Med 3 (1962) 51

DI CHIRO G REAMES P M and MATTHEWS W B RISA ventriculography and RISA cisternography Neurology 14 (1964) 185

DIETZ H ZEITLER E und WOLF R Die szintigraphische Darstellung der Liquorraume mit ^{131}J markiertem menschlichen Serumalbumin (RIHSA) Fortschr Rontgenstr 105 (1966) 537

ELLERTSSON A B Syringomyelidiagnostik (In Swedish) Nord Med 80 (1968) 1638

— (a) Semiologic diagnosis of syringomyelia related to roentgenologic findings To be published in Acta neurol scand

— (b) Syringomyelia and other cystic spinal cord lesions Differential diagnosis based on clinical and cerebrospinal fluid findings and the therapeutic effect of percutaneous cyst puncture To be published in Acta neurol scand

— and GREITZ T Myelocystographic and fluorescein studies to demonstrate communication between intramedullary cysts and the cerebrospinal fluid space To be published in Acta neurol scand

GARDNER W J Hydrodynamic mechanism of syringomyelia its relationship to myelocele J Neurol Neurosurg Psychiat 28 (1965) 247

HEINZ E R SCHLESINGER E B and POTTS D G Radiologic signs of hydromyelia Radiology 86 (1966) 311

HILDITCH T E Radiation dose in isotope encephalography Lancet 1968 II p 573

HUBNER K F and BROWN D W Scanning of the spinal subarachnoidal space after intrathecal injection of I^{131} labeled human serum albumin J nucl Med 6 (1965) 465

MCHILL J REEVE T S and FIGGIS P M Measurement of the mass of the thyroid gland in vivo Amer J Roentgenol 94 (1965) 828

nature of the cyst by studying the rate at which isotopes are reabsorbed from the cyst fluid The relatively rapid elimination of the injected isotope from spinal cord cysts, especially flaccid ones, means that the calculated maximum radiation dose of 250 rad at myelocystography should be reduced by a factor of more than 10

During isotope myelography after lumbar injection in cases of flaccid cyst (syringomyelia hydromyelia) the tracer reached the cerebrospinal fluid space in the skull within the ordinary time, this suggests that there was free circulation within the subarachnoid space Residual activity in thoracic and cervical segments after the isotope has left the basal cisterns may be caused by retention of the tracer in a cyst in communication with the subarachnoid space Similar observa tions have been made in scans after suboccipital injection in cases of cisternal arachnoiditis (DIETZ et coll) A late uptake has been observed in a case of spinal lymphosarcoma and was thought to be due to capillary extravasation within the tumor (HUBNER & BROWN) Further experience is necessary before it can be decided whether isotope myelography can be used to confirm the diagnosis in cases of clinically probable syringomyelia

Partially fluctuating cysts do not differ in isotope myelography from other intra or extra medullary processes They may block the spinal cerebrospinal fluid circulation and this seems to allow a differentiation from syringomyelia cysts

Acknowledgement

The authors wish to thank Mr Lars Johansson physicist at the National Institute of Radiation Protection for calculating the radiation dose in the myelocystographic examina tions

SUMMARY

Isotope myelocystography with direct injection after percutaneous puncture and isotope myelography after lumbar intrathecal injection of RIHSA have been used to examine nine patients with spinal cord cysts The value of these methods in the diagnosis and differential diagnosis and for establishing cyst size is discussed

ZUSAMMENFASSUNG

Isotopenmyelocystographie mittels direkter perkutaner Injektion und Isotopenmyelographie nach Lumbalpunktion und intrathekaler Injektion von RIHSA wurde bei der Untersuchung von neun Patienten mit Cysten des Ruckenmarkes angewandt Der Wert dieser Methoden zur Feststellung der Grosse der Cysten und zur Diagnose und Differentialdiagnose wird be sprochen

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UPTAKE OF ^{85}Sr IN OSTEOARTHROSIS OF THE SPINE IN MAN

by

JOSEPH C DEFIORE and BO E R NILSSON

Osteoarthrosis of the knee and hip causes increased uptake of ^{85}Sr on the affected side about double that on the uninvolved side (DANIELSSON et coll 1963) When digital scintimetry was used in conjunction with focussed collimator geometry permitting a more defined anatomical resolution localized areas of uptake exceeding five times the normal were demonstrated presumably representing a localized rapid bone turnover (BAUER 1968 BAUER & SMITH 1968)

With regard to spinal osteoarthrosis (spondylosis deformans) some data, demonstrating a local uptake of ^{85}Sr in osteoarthrotic changes in the spine, have been published (BAUER & SCOCCIANTI 1961) No data indicating whether the spine actually takes up more ^{85}Sr in cases of generalized osteoarthrosis are available however

The objective of the present study was to evaluate the total uptake and the distribution of ^{85}Sr in the osteoarthrotic as compared to the normal spine

Material Sixty individuals were included in the study They presented without history physical findings or radiographic evidence of disease or injury to the spine other than osteoarthrosis, and no symptoms of other spinal pathologic conditions during an average of a 6 month follow up after scintimetry were noted The patients were examined because of back pain (45 cases) or secondary to investigations because of skeletal lesions not involving the spine (15 cases)

Submitted for publication 10 April 1968

PERRYMAN C R NOBLE P R and BRAGDON F H Myeloscintigraphy A useful procedure for localization of spinal block lesions Amer J Roentgenol 80 (1958) 104
WACKENHEIM A Isotopen Myelographie Radiologe 5 (1965) 484
WESTBERG G Differentiering mellan cystisk och solid process i ryggmargen vid gasmyelografi (In Swedish) Nord Med 74 (1965), 822
— Gas myelography and percutaneous puncture in the diagnosis of spinal cord cysts Acta radiol (1966) Suppl No 252
WICKBOM I and HANAFEE W Soft tissue masses immediately below the foramen magnum Acta radiol Diagnosis 1 (1963) 647

Fig 1 Relationship of detector isoresponse lines and the spine

coordinates (Fig 2) The detector was calibrated so that the actual count rates could be compared from case to case

In 56 of the sixty cases in the study whole body retention was measured at the day of the injection and at the day of scintimetry the latter was expressed as a percentage of the former by comparison to standard The following data were accumulated from the scintimetric investigation

1 *Average count rate* being the average of all the counts over the spine This variable is a measure of the total uptake of ^{85}Sr in the spine in normal as well as in osteoarthrotic subjects

2 *Highest count rate* being the highest single count rate of the entire spine and a measure of the hottest spot in the spine

3 *Ratio highest count rate to average count rate* representing a measure of the magnitude of the uptake in the hottest spot in the spine

Table

Variables in osteoarthrosis of the spine

	Radiological classification		
	None	Less severe	More severe
Sex			
Males	11	8	5
Females	9	13	14
Total	*20*	*21*	*19*
Age (average years)			
Males	*42*	*61*	*69*
Females	38	60	68
Average (±S E)	40 ± 3	61 ± 2	68 ± 2
Whole body retention (% dose)	30 1 ± 2 0	30 5 ± 2 2	33 5 ± 3 1
Ratio highest count rate/average count rate (Average ±S E)	1 6 ± 0 02	1 80 ± 0 08	1 9? ± 0 11

The cases were divided into three groups (1) *no osteoarthrosis*, with normal spine roentgenograms, (2) *less severe osteoarthrosis*, with small osteophytes and narrowing of the intervertebral spaces on one or more levels, and (3) *more severe osteoarthrosis*, with narrowing or total closure of one or more intervertebral spaces, large osteophytes sometimes bridging the intervertebral spaces, sclerosis of the vertebral bodies and deformity of the spine configuration (see the table for group, sex and age distribution)

Method The data were obtained by means of a digital step scanner (Smith et coll 1966, Bauer & Smith 1968, DeFiore & Lindberg unpubl) and a whole body counter (Smith 1966) The measurements were obtained approximately two weeks following intravenous injection of 100 μCi of ^{85}Sr Spinal scintimetry was performed in all cases

The patient was placed in supine position on a plexiglass stretcher with the face of the focusing collimator of the scintillation detector moving under the stretcher (Fig 1) The detector was set to move every 10 seconds at 1/2 inch (1 27 cm) increments across the spine with 1 inch (2 54 cm) increments between the scan lines

With the patient in the same position, a roentgenogram of the spine was obtained which included radio opaque coordinates built into the stretcher Numbers representing background corrected count rates were then superimposed on a diagrammatic representation of the spine by means of the known

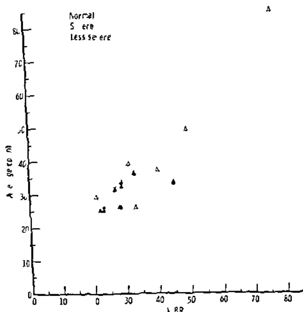


Fig 3 Relationship of the average count rate to whole body retention in non osteoarthrotic and osteoarthrotic spines Covariance analysis revealed no significant difference between the groups

compared there was a significant difference between the osteoarthrotic and the non osteoarthrotic subjects This seems to indicate the presence of one or more small localized areas of high uptake in the osteoarthrotic spines In general these areas are not of such magnitude or quantity to reflect on the uptake of the entire spine nor even remotely comparable to the peaks found in the osteoarthrotic knee

There are significant age differences among the three groups reflecting the increasing incidence of osteoarthrosis with age (Table) HULT (1953) found in population studies that osteoarthrosis of the spine was a common manifestation of increasing age without significant relationship to clinical symptoms Similar conclusions were drawn from studies in dogs by MORGAN (1967) The present study supports the concept of spinal osteoarthrosis as a progressive disorder without the intense response from the bone tissue demonstrated in osteoarthrosis of the large joints

The presence of smaller areas of increased uptake may influence the interpretation of back scans in the diagnosis and localization of spinal lesions However the uptake in these hot areas was of less order of magnitude than

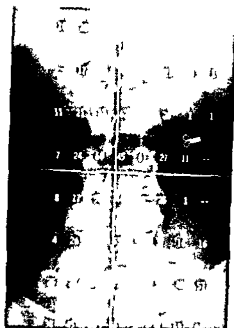


Fig 2 Digital printout displayed on a spine roentgenogram

When the statistical methods were used for the analysis of the data, probability levels of over 95 % were considered significant

Results and Discussion

1 The average count rate was significantly related to whole body retention (Fig 3)

2 Whole body retention did not differ between the three groups (see Table)

3 At any given whole body retention there were non significant differences in the average count rates between the groups (Fig 3)

4 The ratio of the highest count rate to average count rate was significantly higher in the osteoarthrotic spines (Table)

The total uptake of ^{85}Sr in the osteoarthrotic spines did not differ significantly from that of the non osteoarthrotic spines, nor was there any difference between the degrees of osteoarthrosis It must therefore be concluded that the influence even of generalized osteoarthrotic changes of the spine on the uptake of ^{85}Sr is considerably less than in the joints of the hip or of the knee However, when the highest count rates corrected for the average count rate of the spine were

Acknowledgement

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SUMMARY

A comparison of the total uptake of ^{85}Sr was made in cases with and without radiologic evidence of osteoarthrosis, using a method with a high-degree anatomical resolution of the various levels of the spine together with whole body counting. The tracer uptake did not differ significantly between the groups. When local peak values, indicating a limited area with a high uptake, were recorded, these were significantly higher in spines with osteoarthrosis. Such peak values, however, never reached the magnitude of those seen in metastatic disease, spondylitis and other localized spine lesions.

ZUSAMMENFASSUNG

Eine vergleichende Untersuchung der Totalaufnahme von ^{85}Sr in Fallen mit und ohne radiographisch nachgewiesener Osteoarthrose wurde mit Anwendung einer Methode, die eine hohe anatomische Detail-Auflosung der verschiedenen Wirbelsaulenabschnitten erlaubt, zusammen mit Ganzkorperzahlung vorgenommen. Es erwies sich, dass die Differenz in der Traceraufnahme zwischen den beiden Gruppen nicht signifikant war. Wenn lokale Maximalwerte beobachtet wurden, die begrenzte Abschnitte mit hoher Aktivitat indikierten, lagen diese Werte wesentlich hoher in Wirbelsaulen mit Osteoarthrose. Diese Hohepunkte waren jedoch nie in der Grosse wie die bei Metastasen, Spondylitis und anderen lokalisierten Wirbelsaulenlasionen auftretenden.

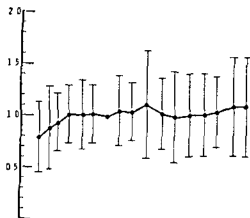
RÉSUMÉ

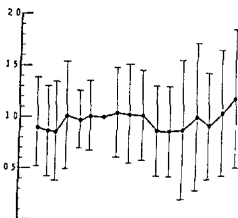
Les auteurs ont comparé la fixation totale de ^{85}Sr dans des cas avec et sans signe radiologique d'ostéo-arthrose vertébrale par une méthode de haute résolution anatomique des différentes parties de la colonne vertébrale en meme temps que par un comptage corporel total. La fixation du traceur n'a pas présenté de différence significative entre les groupes. Les pics localisés indiquant une région limitée de forte fixation sont significativement plus élevés dans les colonnes atteintes d'ostéo-arthrose. Ces pics cependant n'ont jamais atteints l'importance de ce que l'on constate dans les métastases, les spondylites et les autres lésions rachidiennes localisées.

REFERENCES

BAUER, G. C. H.: Clinical use of radioactive isotopes in orthopaedics. The Cornell Veterinarian (1968) Suppl. No. 58.

— and SCOCCIANTI, P.: Uptake of Sr^{85} in non malignant vertebral lesions in man. Acta orthop. scand. 31 (1961) 90.

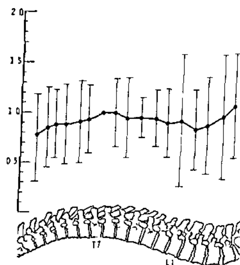




b



a



c

Fig 4 Graphical representation of the total count rates of individual vertebrae as related to Th 7 (average ± 2 S D) (Compare with FELLANDER & LINDBERG 1966) a) Normal subjects b) Less severe osteoarthrosis c) Severe osteoarthrosis

found in vertebral fractures, spondylitis, metastatic disease, and Paget s disease utilizing the same method (DEFIORE & LINDBERG 1968)

The vertebral count ratios for Th 7 in both normal and osteoarthrotic spines are given in Fig 4 The presence of radiographically evident osteoarthrosis, whether severe or not, increases the scatter of the spine count rates throughout the entire spine especially in the lumbar region This increase might occasionally make the diagnosis of a lesion in the lumbar spine difficult and should be taken into account, but in most instances will not interfere with the interpretation of spinal scintimetry

FROM THE UNIVERSITY CLINIC OF NEURORADIOLOGY (DIRECTOR H. H. JACOBSEN)
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ORBITOGRAPHY WITH WATER SOLUBLE CONTRAST MEDIA

by

JØRGEN FOG and JACK LESTER

Orbitography was first performed by STAUNIG & HERRENSCHWAND in 1927 in an attempt to demonstrate the retrobulbar orbital space in unilateral exophthalmos. Numerous contrast media have been used for orbitography. Air formed the first medium and negative contrast media, particularly oxygen, are still preferred by many radiologists. Positive contrast media were introduced in 1939 by THIEL. Oily as well as water soluble media have been employed and have sometimes been followed by complications probably caused by their toxicity. Thorotrast has also been used.

Orbitography performed with modern water soluble contrast media of low toxicity may however now be regarded as an examination accompanied by few sequelae and no more risky than an ordinary neuroradiologic examination. Relatively few reports about orbitography with positive contrast media have been presented. The most important papers are by LOMBARDI & PASSERINI who have performed more than 150 orbitographies without any serious complications.

This paper was presented at the 8th Symposium Neuroradiologicum in Paris 1967. Submitted for publication 16 February 1968.

— and Smith E M ^{85}Sr scintimetry in osteoarthritis of the knee To be published in J nucl Med

DANIELSSON L G DYMLING J F and HERIPRET G Coxarthrosis in man studied with external counting of Sr^{85} or Ca^{47} Clin ortop 31 (1963) 184

DEFIORE J C and LINDBERG L T Unpublished results

FELLANDER M and LINDBERG L Clinical use of radiostrontium in evaluation of spondylitis J Bone Jt Surg 48 A (1966) 1585

HULT L Cervical dorsal and lumbar spinal syndromes A field investigation of a nonselected material of 1 200 workers in different occupations with special reference to disc degeneration and so called muscular rheumatism Acta orthop scand 1954 Suppl No 17

MORGAN JOE P Spondylosis deformans in the dog Acta orthop scand 1967 Suppl No 96

SMITH E M Evaluation of a whole body counter Read at the Annual Meeting of Society of Nuclear Medicine 1966 Charleston U S A

— MATTHEWS JR H G and ANDERSON D G A multifunction digital scintillation scanning system with a clinical example (Abst) J nucl Med 7 (1966) 793



F g 3 Marked ele tion of the muscular cone caused by a mucocele from the frontal s nus occupy ing the infer or half of the orbit cloud ng of the frontal s nus destruction of the medial part of the supra bital m gin had occurred

The dominating sign was unilateral exophthalmos which was present in 23 patients Nearly half the number of these complained of double vision caused by muscular paralysis and dislocation of the eyeball Two infants with optic nerve glioma had no sight in the affected eye The tumor was palpable in four patients



F g 4 Optic ne ve gl m The diameter of the optic fo amen was nlarged by 40



Fig. 1. The needle in situ, inserted from the temporal aspect of the inferior orbital margin to a depth of about 4 cm.

Material. We have carried out 32 orbitographies with water soluble contrast media in our department during the past five years, 21 of them in 1967. The number of patients was only 29, since in three of them the examination was performed twice. Seventeen were females and twelve males. The ages ranged from 6 months to 76 years but half the number of patients were between 40 and 60 years of age.



Fig. 2. Normal orbitogram with the contrast medium spread inside the muscular cone. Indentations of the recti muscles are seen in the a.p. view; the central defect corresponds to the optic nerve.




F 6 F brosa oma Almost the same d splacement as n fig 5 bt t the contour more regular destruct n cf th o b tal roof




F g 7 (nous hemangioma. The largest f sev al calcificat ons was tuat d nter orly in the pern ed al qu d ant



Fig 3 Mixed tumor of the lacrimal gland Medial and downward displacement of the muscular cone clear cut indentation in the superolateral quadrant

Technique The examination is performed on a skull table with the patient supine Conventional films of the orbit in a p and lateral projections are first obtained A needle, with an outer diameter of 0 40 mm and 5 cm long is inserted from the temporal aspect of the inferior orbital margin in a superior and medial direction, close to the eyeball, with the ordinary technique used for retrobulbar anesthesia The needle is inserted to a depth of about 4 cm, the patient being asked to report any disturbance of vision It is not uncommon for a slight resistance to be felt when the needle reaches the muscular cone The position of the tip of the needle is checked in a p and lateral views and when it is considered to lie inside the muscular cone, 3 to 4 ml of a mixture of equal parts of Urografin 45 % and lidocain 2 %, corresponding to a 22 % solution of Urografin, are slowly injected The patient is again asked to report any visual disturbances, and should these occur the injection is interrupted and the position of the needle checked by films to avoid injection into the optic nerve The patient will normally feel slight tension behind the eye after injection of about 3 5 ml of the fluid The needle is then removed and a sterile eye bandage applied, this is left on for 24 hours Films are obtained in a p lateral and p a projections, the series being repeated after 5 to 10 minutes, when there is a more even distribution of the medium After 20 minutes the medium will have almost disappeared Stereoscopic films as well as films obtained with the subtraction technique are sometimes useful

Complications. Three orbitographies were unsuccessful. The contrast medium was injected outside the muscular cone in one patient and into the capsule of Tenon in another. In the third patient the medium lay along the optic nerve and could be followed into the subdural space above the sella turcica. The vision of the eye was seriously affected by this examination but the day after it was normal. No permanent complications occurred.

Conclusions

Orbitography with water soluble contrast media appears to produce valuable information in patients with possible retrobulbar tumors. It indicates the site and size of the growth but naturally provides no information regarding the type. It is consequently necessary to perform supplementary examinations such as orbital arteriography or venography.

The present writers prefer orbitography with water soluble media to pneumoorbitography because tomography is then unnecessary and the projections are simple.

The examination causes little discomfort, it takes only half an hour and requires no special apparatus. Supplemented by orbital angiography it solves most of the problems in a variety of orbital diseases.

LOMBARDI & PASSERINI have reported a success rate of 80 per cent which means that the diagnostic results are approaching the level of the conventional neuroradiologic examinations. This illustrates the benefit of concentrating uncommon examinations in a few departments so as to obtain the most accurate results with a minimum of risk.

SUMMARY

Thirty two consecutive orbitographies performed with water soluble contrast media are reviewed and the technique is described. Radiographic evidence of a retrobulbar expansive process was confirmed at operation in fifteen patients. Orbitography was false positive in one patient. No permanent complications occurred but one patient had transient amaurosis.

ZUSAMMENFASSUNG

Eine Serie von 32 konsekutiven Orbitographien mit wasserlöslichen Kontrastmitteln und die Technik werden beschrieben. Radiographische Zeichen eines retrobulbären Tumors wurden bei der Operation in 15 Patienten bestätigt; nur einmal ergab sich ein falsch positiver Befund. Keine andauernde Komplikationen traten auf; nur eine vorübergehende Amaurose wurde in einem Patienten beobachtet.

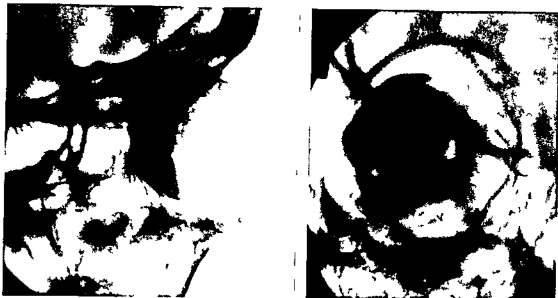


Fig 8 Unintentional injection into the capsule of Tenon There is a homogenous layer of contrast medium following the contour of the eye ball and a marked defect caused by the optic nerve Repeat orbitography revealed normal conditions

Results

Normal conditions were noted in 12 of the 29 patients examined, 17 had signs of a retrobulbar expansive process, 16 have been operated upon and one patient is awaiting operation

The radiologic findings were confirmed in 15 patients A tumor of the optic nerve was diagnosed in a child of 2 5 years with unilateral papillary edema of 2 diopter but operation revealed normal conditions

The final diagnosis in the fifteen patients with retrobulbar growth was as follows pathologic lacrimal glands in 3 cases (mixed tumor in one case, inflammatory processes two cases), optic nerve glioma, neurofibromatosis Recklinghausen, dermoid cyst and mucocele each one in 2 cases, and one case of each one of the following lesions fibrosarcoma, pseudotumor, cavernous hemangioma, and osteoma

Carotid angiography was performed in 50 per cent of the patients without pathologic changes The patient with a cavernous hemangioma was unfortunately not submitted to angiography

The conventional films of the orbit were found to be normal in 80 per cent of all the patients The remainder had destruction or calcifications, and in one patient the optic foramen was enlarged

Complications Three orbitographies were unsuccessful The contrast medium was injected outside the muscular cone in one patient and into the capsule of Tenon in another In the third patient the medium lay along the optic nerve and could be followed into the subdural space above the sella turcica The vision of the eye was seriously affected by this examination but the day after it was normal No permanent complications occurred

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RÉSUMÉ

Les auteurs passent en revue trente deux orbitographies consécutives par des moyens de contraste hydrosoluble et décrivent la technique de cet examen. Chez 15 malades l'opération a confirmé le diagnostic de lésion expansive rétrobulbaire. L'orbitographie a été faussement positive dans un cas. Il n'y a pas eu de complications permanentes mais un malade a eu une amaurose transitoire.

REFERENCES

ANANOS V. A. Orbitografia con diatrizoate de sodio (Hypaque). Sem. med. 122 (1963) 165.

COWIE J. W. and GROVES J. S. Preliminary report on the use of contrast media in orbital radiography. Brit. J. Ophthal. 39 (1955) 283.

KOLNIG F. Zur Orbitographie. Ophthalmologica 127 (1954) 283.

LOMBARDI G. Orbitography with water soluble contrast media. Acta radiol. 47 (1957) 417.

— Radiology in neuro ophthalmology. Williams & Wilkins Co. Baltimore 1967.

— and PASSERINI A. The orbit and contrast media. Arch. Ophthal. 78 (1967) 306.

MANCHESTER P. T. and BONMATI J. Iodopyracet (Diodrast) injection for orbital tumors. Arch. ophthal. 54 (1955) 591.

STAUNIG K. und VON HERRENSCHWAND F. Experimentelle Versuche der Röntgendifferenzierung des Augapfels. Fortschr. Roentgenstr. 36 (1927) 372.

THIEL R. Cited by KOLNIG.

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PULMONARY SEQUESTRATION

by

ROLF KOHLER

Pulmonary sequestration is a congenital malformation consisting of a non functioning and usually cystic bronchopulmonary mass separated from normal pulmonary tissue The lesion is supplied by one or several systemic arteries arising from the aorta or its branches and its bronchi do not communicate with the remainder of the bronchial tree

Intralobar sequestrations are contained within the normal visceral pleura while extralobar sequestrations lie outside the pleural sac and above or below the diaphragm There are dissimilarities also in the relation to arteries and veins connection with the esophagus or stomach and in further anomalies the patient s age etc as pointed out by PRYCE (1964) and especially by SMITH (1956)

These congenital malformations of the lung which are sometimes difficult to classify are varyingly grouped by different authors SCHUSTER & HUZLY (1964) presented a classification derived from SPENCER (1962) which appears to be simple and clear (1) localization within the normal pleural sac without connection with the bronchi or intralobar sequestration (2) localization outside the normal pleural sac without connection with the bronchi or extralobar sequestration (3) localization outside the normal pleural sac connected with an acces-

Submitted for publication 16 September 1968

sory bronchus that runs from the foregut or the normal bronchial system, i.e. an accessory lung, or Nebenlunge.

Sequestrations are thus connected with a pulmonary lobe and situated in or contiguous to it, whereas accessory lungs, like an accessory spleen, are completely isolated and have no contact with a lobe. The classification is complicated by the fact that intralobar sequestrations are sometimes connected with the esophagus but never with any of the bronchi. Most authors consider an aberrant vascular supply to the sequestrations to be of pathognomonic significance, but SCHUSTER & HUZLY (1964) were not of this opinion. In intralobar sequestration, the venous drainage is to the pulmonary veins, in extralobar sequestration to the systemic veins.

The significance of pulmonary sequestration lies in the fact that most of the patients have suffered from recurrent respiratory infections with productive cough for many years. The roentgenologic changes may be suggestive of tumour or cyst. Sooner or later, surgery is indicated.

An isolated systemic arterial anomaly to the lung without associated bronchopulmonary pathologic features was — according to BESKIN & BATON (1961) — described in 1777 by HUBERT. Pulmonary sequestration was probably reported for the first time by ROKITANSKY (1861) and REKTORZIK (1861). However it was not until the 1940's that HARRIS & LEWIS (1940), ARCE (1943) and above all PRYCE (1946) described the condition as a clinically important, though relatively rare, entity. According to RANNIGER & VALVASSORI (1964) more than 250 cases of intralobar pulmonary sequestration have been reported in the literature. In Scandinavia, TOSATTI & GRAVEL (1951) published two cases, JENSEN & WOLFF (1956) one, TURUNEN & HARJOLA (1957) one, BRUNNER (1958) four, MARTINY (1959) one, KYLLONEN (1963) five, NIELSEN (1964) two and HEIKEL & PASILA (1967) nine cases.

The surgically important aberrant vessels have been diagnosed pre-operatively by aortography in a number of cases (KENNEY & EYLER 1956, PAPILLON et coll., AINSWORTH 1958 and others). RANNIGER & VALVASSORI (1964) took angiographic diagnosis even further by selective catheterization of the abnormal vessel, and RIBAUDO, ROSSI & COMER (1966) reported a further case.

Various theories regarding the embryonic origin of sequestration have been presented in great detail by several authors and opinions diverge considerably. A condensed but relatively complete survey of the various theories of the etiology of the condition may be found in NIELSEN's (1964) study.

The patients are usually young, about two thirds being under thirty years of age, according to TURK & LINDSKOG (1961). The left lower lobe is the site of the sequestration in about two thirds and the right lower lobe in almost one third of the cases.

Most of the cases have a history of frequent upper respiratory tract infections with febrile episodes Profuse chronic expectoration may also occur although acute and even completely asymptomatic cases are also encountered, for example at routine mass miniature radiography Thus the diagnostic symptoms and signs of sequestrations are atypical

Pathologic features The sequestered portion of the lung is incorporated in or adjacent to the normal lung and in almost all cases is situated in the posterior basal segment of the lower lobes The pathologic lung segment is the site of cystic degeneration combined with bronchiectasis and more or less abundant fibrotic tissue elements There is no communication between the sequestered lung segment and the normal bronchial tree (TOSATTI & GRAVEL SCHUSTER & HUZLY) The bronchogenic cyst on the other hand is characterised by a communication of this kind The cystic cavities often contain fluid or mucus

Perforations into the adjacent lung tissue are fairly frequent leading to infection and clinical exacerbations These episodes alternate with quiter periods in which resorption and expectoration dominate Cysts having an establi hed bronchial communication may contain air in addition to secretion Besides the spread of infection per continuitatem hematogenic spread is also possible

The sequestered lung segment is usually supplied by an extremely large artery of elastic type coming off the aorta supra or infradiaphragmatically seldom from one of the rami of the aorta TURK & LINDSKOG encountered multiple arteries in seventeen out of 114 cases Venous drainage was usually via the pulmonary veins Systemic return to the right heart was reported in only six of the 114 cases Extralobar pulmonary sequestrations usually drain to the azygos or hemiazygos system

Roentgen appearances

Conventional films may reveal the intralobar sequestration as a homogeneous or cystic air containing mass usually oval but sometimes completely irregular situated in the posterior basal segments of the lower lobe more often on the left side The roentgen appearances not infrequently vary from one examination to another Extralobar sequestrations have a marked left preponderance and according to PRYCE their association with diaphragmatic hernia has been established

CALLAGHER LYNCH & CHRISTIAN (1957) in one case and HEIKEL & PASILA in two cases succeeded in radiographically demonstrating the aberrant artery without tomography or angiography KILMAN BATTERSBY & TAYBI (1965) published a conventional film in which a distinct infradiaphragmatic extension

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Case 8 Cough for some time Detection Fluoroscopy of the lungs Abnormal arteries 7+8 mm supradiaphragm



Case 9 Pneumonia twice Detection Roentgen examination of chest Abnormal artery 4 mm subdiaphragm



Case 10 Pneumonia five times. Detection Roentgen examination of chest Abnormal artery 8 mm supradiaphragm



Case 11 Asymptomatic Detection Mass miniature radiography Abnormal arteries 5+2 mm supradiaphragm



Case 12 *Haemoptysis 6 months previously* Detection Roentgen examination of chest Abnormal arteries 5 mm subdiaphragm plus 4+4 mm supradiaphragm



Case 13 Pain in left chest for some years Detection Fluoroscopy of chest Abnormal arteries 1+1 mm supradiaphragm



Case 14 Lassitude for some months Detection Mass miniature radiography Abnormal arteries 2+1+1+1 mm supradiaphragm

Case 1 Cough and expectoration for some months Detection Mass miniature radiography Abnormal artery 7 mm subdiaphragm



Case 2 Temperature and expectoration recurrent for three months Detection Mass miniature radiography Abnormal artery 8 mm supradiaphragm



Case 3 Pain in chest and temperature for 10 years Detection Mass miniature radiography Abnormal artery 9 mm subdiaphragm



Case 4 Expectoration and cough since childhood Detection Roentgen examination of chest Abnormal artery 9 mm subdiaphragm



Case 5 Asymptomatic Detection Mass miniature radiography Abnormal artery 13 mm subdiaphragm



Case 6 Attacks of temperature and expectoration for 12 years Detection Roentgen examination of chest Abnormal artery 5 mm supradiaphragm



Case 7 Cough and haemoptysis 2 years previously Detection Clinical symptoms Abnormal arteries 7 + 9 mm supradiaphragm



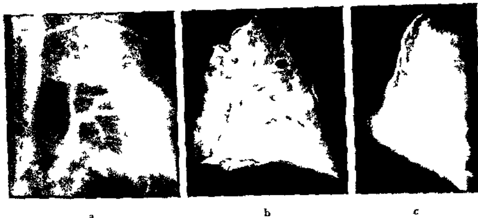


Fig. 3 Case 10 a) Slightly left-oblique aortogram. An aberrant artery 10 mm wide arises from the aorta just above the diaphragm b) and c) Ap and lateral roentgenograms of the air filled resected sequestration Contrast medium in aberrant artery (bottom) and vein (cranially)

therefore is the method of choice when there is suggestion of sequestration (For literature see RANNIGER & VALVASSORI 1964 RUBIN et coll 1966) It may be worthwhile complementing the injection of the aorta with a selective study

Material The present material consists of fourteen operatively verified cases of pulmonary sequestration six of which were examined angiographically The cases are presented in a Table together with a few essential data on each A case examined by pneumomediastinum and the angiographically examined cases are now described in greater detail Two border line cases (Cases 15 and 16) which do not belong to the material and in which the diagnosis is a question of classification are also included

Case reports

Case 1 Woman aged 46 had suffered for three months from recurrent fever with productive cough A conventional film of the chest revealed a *homogeneous* bipartite oval expansion in the left lower lobe The finding at routine mass miniature roentgenography two years earlier had been negative Pneumomediastinum a 3 to 4 cm wide connection extended from the lesion to the mediastinum (Fig 1) Left side thoracotomy revealed an 8 mm wide artery that arose from the aorta 3 cm above the diaphragm and ran to the lower lobe The latter was removed and found to consist almost *completely* of a mass containing green, thick liquid

Case 7 Boy aged 18 years had had left sided pleurisy at the age of 8 years and a year later hilar tuberculosis of the left lung He made a complete recovery A year previously



Fig 1 Case ? Pneumomediastinum Mass in left lower lobe with a 4 cm wide connection to mediastinum and aorta





Fig 2 Case 7 A p (left) and left oblique (right) thoracic aortograms Two aberrant arteries 8 and 9 mm wide arise from the aorta just above the diaphragm and course dorsolaterally to the sequestered pulmonary segment

from an irregular mass in the right lower lobe was demonstrated arteriographically *as representing* a *large aberrant artery However conventional films are* usually not sufficient for an accurate diagnosis

Bronchography is of diagnostic value because the bronchial tree is numerically complete in the sequestrations The bronchi in the vicinity are however usually displaced ventrally and laterally

ROUAN, BARROUX & CAMAIN (1958) demonstrated anomalous vessels tomographically In WEILAUER's (1962) opinion tomography is always indicated when pulmonary sequestrations are considered probable but others have not supported his view to any appreciable extent

An artificial pneumoperitoneum may reveal aberrant vessels that pass subdiaphragmatically from the aorta, as stated by HILL MUTO MANI & DOZIER (1964) and HEIKEL & PASILA The method in diaphragmatic lung processes is valuable in other respects too, and has therefore gained a special place As the *aberrant vessel originates subdiaphragmatically in only one case out of four* the significance of a pneumoperitoneum in sequestrations is not unduly great

The almost pathognomonic aberrant arteries to the sequestration are dem*onstrated most reliably by angiography* An injection of contrast medium into the lower part of the thoracic aorta of young patients via a catheter introduced femorally cannot be regarded today as a major intervention Angiography



a b



c

Fig 5 Case 11 a) Thoracic aortogram Two aberrant arteries 3 and 5 mm wide arise from the aorta just above the diaphragm and run to the sequestered pulmonary segment b) and c) Selective angiograms of the lower wider artery At 0 5 seconds (b) the arteries in the basal part of the sequestration are filled At 5 seconds (c) both arteries and veins the latter draining into the left pulmonary vein a filled

following a month of hemoptysis he had been admitted to hospital with probable bronchiectasis

Conventional films revealed diffuse infiltrations in the left lower lobe and bronchography slight displacement of a complete bronchial tree Pulmonary sequestration was considered likely and thoracic aortography was performed This disclosed two short arteries 8 and 10 mm in width which ran 3 and 4 5 cm respectively from above the diaphragm to the altered area (Fig 2) Left side thoracotomy was performed The accessory arteries were localized to the site revealed by aortography The lower lobe was extirpated The specimen contained postero basally a cyst containing grayish pus

Case 10 Boy aged 18 years had had pneumonia in 1955 1957 1958 and 1960 He again developed pneumonia in 1966 and roentgen examination disclosed an infiltration basally in

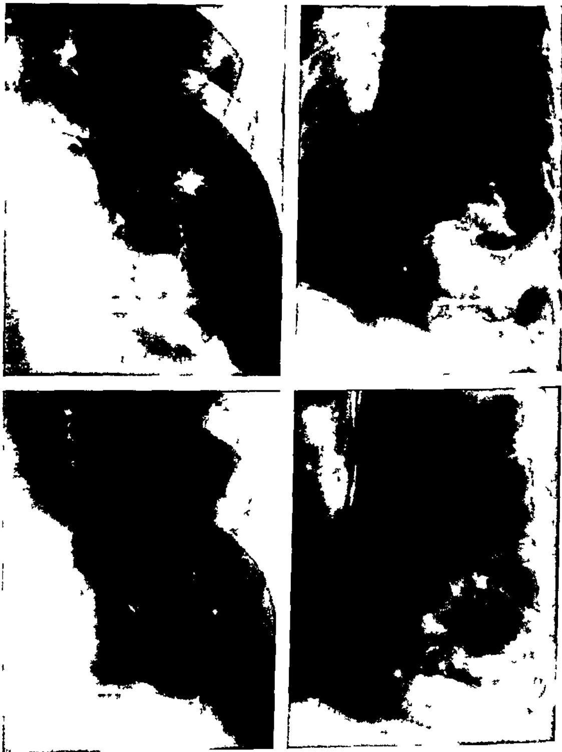


Fig 4 Case 11 Conventional roentgenograms *Upper views* irregular infiltration including air and fluid filled cyst dorsobasally in the left lung *Lower views* one month later the infiltration has changed to multicystic lesions




Fig 8 Case 15 Right bronchography Dorsally displaced distorted dilated and partially cystic ramifications There is no contrast medium in the sequestered small cystic anterobasal part of the right lung



Fig 9 Case 16 Left bronchography Thin walled longish cavities in apical segment of left lower lobe

examination was continued as elective angiography with catheterization of the lower artery (Fig 5b) After two successive injections of contrast medium veins discharging into the pulmonary vein were filled at 2 5 and 0 75 seconds respectively Optimal filling of the veins occurred at 5 seconds (Fig 5c)

The dye test suggested a peripheral shunt but its magnitude was difficult to determine Lobectomy was performed A postoperative dye test revealed no appreciable difference from the previous test In addition to the vessels demonstrated angiographically the operation disclosed two other veins barely 1 mm wide leading directly from the vena cava to the sequestrum

Case 12 Boy aged 16 years with haemoptysis about 8 months previously An expanding process in the left lower lobe connected to the diaphragm was diagnosed radiographically Antibiotics produced no change Bronchography had demonstrated a *complete but displaced* bronchial tree Aortography disclosed a wide artery along the left border of the aorta from the coeliac artery to the mass (Fig 6) Widened costal veins were connected to the sequestration and other veins emptied into the pulmonary vein

Pulmonary intralobar sequestration indicated thoracolaparotomy and a richly vascularized mass adherent to the diaphragm and the lung was extirpated Microscopically it proved to be fibrotic and chronically inflamed There were signs of a bronchopulmonary genesis supporting the view of the presence of a pulmonary sequestration

Case 13 Man aged 58 without earlier pulmonary disease but who had undergone [illegible] was found to have a mass in the postero basal part of the left lung Pulmonary sequestration was considered probable Unsatisfactory aortography revealed no aberrant arteries although it was thought that they could be just seen when the films were re-examined The lower lobe was removed The apex of the postero basal segment was found to contain pus and to be connected to the aorta by a few arteries the calibre of



Fig 6a



Fig 6b



Fig 7

Fig 6 Case 12 Thoraco abdominal aortograms at 1 second (a) and 3 5 seconds (b) An artery runs along the left border of the aorta from the coeliac artery to the sequestration widened costal arteries also send out branches to the mass b) Contrast accumulation in kidney (bottom) spleen and sequestration there are veins from the sequestration to the pulmonary vein

Fig 7 Case 14 Aortogram at 1 second Four fine arteries to the sequestration from the thoracic aorta are visible near the diaphragm

the left lower lobe As the appearances did not change therapy for tuberculosis was prescribed for two months

The patient was then moved to our hospital where thoracic aortography indicated a sequestration with a 10 mm wide artery running from the aorta immediately above the diaphragm (Fig 3a) Sequestrectomy was performed The lung segment was adherent It contained no anthracosis spots but necrosis fibrosis and chronic inflammation were observed at microscopy The specimen was filled with air and contrast medium was injected into the artery and vein (Fig 3 b and c)

Case 11 Boy aged 17 years Routine mass miniature radiography revealed infiltration of the left lower lobe The patient was admitted to hospital for three months with probable active tuberculosis Therapy was then continued for one year No bacilli were found at any time Apart from occasional coughing he was asymptomatic

The patient was referred for possible operation for bronchiectasis Roentgen examination suggested the possibility of sequestration Conventional monthly films had revealed considerable variation in the basal changes (Fig 4)

Thoracic aortography confirmed the diagnosis of sequestration (Fig 5a) with two supradiaphragmatic arteries the upper being 3 mm and the lower 5 mm in width The



Fi 8 Ca e 15 R ght broncho̧raphy Dorsally d splaced distorted dilated and pa tially cystic ram fications The e s ro contrast medium in the sequeste ed small cystic antero b s l part of the right lung



Fig 9 Case 16 Left bronchography Thin walled lon ish cavities in apical segment of left lower lobe

examination was continued as elective angiography with cathet rization of the lower artery (Fig 5b) After two successive injections of contrast medium veins discharging into the pulmonary vein were filled at 2 5 and 0 75 econds respe tively Optimal filling of th veins occurred at 5 econds (Fig 5c)

The dye test uggested a peripheral shunt but its magnitude was difficult to determine Lob ctomy was performed A po toperative dye te t revealed no appreciable difference from the pr vious te t In addition to the ve sels demonstrated angiographically the operation discl d two other veins barely 1 mm wide leading directly from the vena cava to the seque trum

Case 17 Boy aged 16 years with haemoptysis about 8 months previously An expanding pr c s in the left lower lobe connected to the diaphra m was diagnosed radiographically Antibiotics produced no change Bronchography had demonstrated a complete but di pla ed br nchial tree Aortography disclo ed a wide artery along the left border of the aorta fr m the coeliac artery to the mas (Fig 6) Widened costal veins were connected to the eque tration and other vein emptied into the pulmonary vein

Pulmonary intralobar seque tration indicated thoracolaparotomy and a richly vas ularized mas dherent to the diaphragm and the lung was extirpated Microscopically it proved to be fibr tic and chronically inflamed There were signs of a bronchopulmonary genesis sup port n the vie of the presence f a pulmonary seque tration

Ca 18 Man, a ed 58 without earlier pulmonary disea e but who had undergone l l ctectomy was found to have a mas in the postero basal part of the left lung Pulm nary seque tration was con idered probable Unsatisfactory aortography revealed no aberr nt arterie althou h it as thought that they could be just seen when the films were re-examined The lo er lobe was removed The apex of the postero basal segment was found to contain pus and to be connected to the aorta by a few arteries the calibre of

a match The pathology report suggested bronchogenic cyst so that a sequestration was etiologically quite reasonable

Case 14 Woman aged 39, in whom roentgenography had disclosed a mass in the dorsal part of the left lower lobe This was connected by four thin supradiaphragmatic arteries to the aorta (Fig 7) The patient at first refused operation but changed her mind and was re admitted in 1968 Left side thoracotomy revealed a mass connected by a tract to the mediastinum Four arteries from the aorta were ligated Veins from the mass emptied into the vena cava inferior There were no adhesions The specimen contained large cystic cavities containing fluid and was according to the pathology report a typical sequestration

Case 15 Man aged 41 years who had had respiratory infection and frequently recurrent pneumonia for 13 years Conventional films revealed marked shrinkage of the right half of the chest which contained the heart in its entirety Bronchography showed the bronchi to be markedly deformed and considerably dilated (Fig 8) Right thoracotomy disclosed that the lung was supplied by half a dozen 3 mm wide arteries which ascended through the diaphragm towards the basal part of the parenchyma The hilar region contained only two 6 mm wide vessels probably normal pulmonary arteries A pulmonary vein to the upper lobe, which was much narrower than normal was ligated Right pneumonectomy was performed The lung was found to be cystic The bronchi led to large cavities which contained mucus and pus Microscopic examination revealed congenital dilatation and inflammation

Case 16 Woman aged 53 with episodes of haemoptysis Thin walled longish cavities in the apical segment of the left lower lobe were outlined at bronchography (Fig 9) The segment was extirpated and was found to be connected to the aorta by two anomalous tortuous arteries No normal pulmonary arteries to this segment were present The operation specimen showed a cystic cavity in the apical segment with broad connection to the bronchial tree The pathology report stated lung tissue differing from normal in its general structure and displaying several profusely ramifying bronchi irregular cavities lined by cuboidal bronchiolar epithelium in several situations numerous blood vessels thick walled and often of the elastic type appearances compatible with pulmonary sequestration

Discussion

Intralobar sequestrations are said invariably to drain into the pulmonary veins This material would thus include ten typical cases of intralobar sequestrations according to SPENCER s classification In addition, there are two atypical ones (Cases 8 and 12) Case 8, with venous drainage from the sequestrum to the vena cava, must be included in this group because of the typical intralobar localization Case 12 in addition to venous drainage to the pulmonary vein, had minute veins discharging into the vena cava Similar cases have been reported earlier The survey by TURK & LINDSKOG included six cases out of 114 in which veins accompanying the anomalous artery joined in the systemic return to the right heart

There remain two cases of extralobar sequestration The sequestration in Case 5 was associated with an abnormal distribution of the lobes of the left lung

The right kidney was also abnormal This agrees with earlier observations of associated abnormalities (SMITH) The extralobar sequestration in Case 14 was typically well demarcated without adhesions The venous drainage was systemic to the vena cava

Intralobar sequestrations were encountered on the left side in ten out of twelve cases and both the extralobar cases were also left sided Cysts were evident in the conventional films in six cases and the fluid in the cysts of four cases was at different levels at examinations performed at intervals of a few weeks Similar observations were made by SPENCER and by WYMAN & EYLER (1952) as well as by SCHUSTER & HUZLY although the appearances in the present material were fairly typical of cyst formations in sequestrations The variability of the roentgenologic finding in these cases is on the whole worth underlining (cf Figs 4 and 5) The chronic course of the disease with asymptomatic periods alternating with respiratory inflammation are noteworthy

Routine miniature radiography is a useful method of detecting sequestrations This examination method led to more thorough investigations and removal of the lesion in six of the fourteen cases The lesion was however at first un detected in two cases

Thoraco-abdominal aortography must be resorted to if an accurate pre operative diagnosis is required It must consequently be performed on fairly broad indications in cases of possible sequestration Aberrant vessels constitute risks in surgery and ought to be demonstrated Selective catheterization can moreover refine the diagnosis above all by disclosing the venous drainage from the sequestrum However in the presence of heavy vascularization aortal deposition of the contrast medium may also be enough to bring out the venous drainage (Fig 9)

Selective angiography in Case 11 demonstrated the pulmonary vein in two successive injections at 2 50 and 0 75 seconds which is remarkably quick The structure of the blood circulation in the sequestrations suggested a certain degree of shunting from the arterial to venous flow as the dye test also indicated The time difference in the contrast medium injections may perhaps be interpreted as a sign of the possibility that there is some kind of regulation of flow within the sequestrum Experience of further cases is obviously necessary before tenable conclusions can be drawn on this point

Selective catheterization is not always possible as the arteries are sometimes thin and even difficult to identify (cf Case 13) This case emphasizes that optimal filling of the aorta with contrast medium is essential to prevent misinter pretation of the angiogram Moreover it must be remembered that sequestration may lie more or less directly dorsal to the aorta on the left of the vertebral column requiring left oblique projections for the achievement of optimal demonstration

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Clinic during the 1950's covered practically all Finland, and even now, during the 1960's comprises a good half of the total popoulation eleven of the fourteen cases came from a limited area of south eastern Finland where only about 7 to 8 per cent of the population resides Three cases even belonged to the same commune but were not related Intestinal volvulus is also known to be represented to an extraordinarily high degree in this part of Finland It thus appears that pulmonary sequestration is a congenital anomaly the uneven distribution of which among the inhabitants of this country cannot at present be readily explained

SUMMARY

A series of twelve intralobar and two extralobar cases of confirmed pulmonary sequestrations were studied two atypical cases are also described Bronchography tomography pneumoperitoneum and pneumomediastinum are all aid in the diagnosis Aortography is however the method of choice for final confirmation of the anomaly and insures against fatal complications at operation Selective catheterization of the aberrant arteries is indicated for refinement of the diagnosis.

ZUSAMMENFASSUNG

Ein Material von zwolf Fallen von intralobarer Lungensequestration und zwei Fallen von extralobarer Lungensequestration sowie zwei atypische Falle wurde kritisch uberpruft Bronchographie Tomographie Pneumoperitonaum und Pneumomediastinum sind alle gute Hilfmittel bei der Diagnose Aortographie ist jedoch die Methode der Wahl fur die endgultige Bestatigung der Diagnose und verhindert gefahrliche Komplikationen wahrend der Operation Um grossere Genauigkeit in der Diagnose zu erzielen sollte elektive Kathetersierung der abnormalen Arterien angewendet werden

RÉSUMÉ

L'auteur a etudie douze cas de sequestration pulmonaire intralobaire confirmee et deux cas de sequestration extralobaire il decrit aussi deux cas atypiques La bronchographie la tomographie le pneumoperitoine et le pneumomediastin contribuent au diagnostic Cependant l'aortographie est la methode de choix pour confirmer cette anomalie et pour prevenir des complications fatales au cours de l'operation Le catheterisme selectif des arteres aberrantes st indiqué pour préciser le diagnostic

REFERENCES

AINSWORTH J Anomalous blood supply to lung demonstrated by aortography Brit J Radiol 31 (1958) 448

ARCE J Accessory pulmonary artery probably arising from the abdominal aorta J thorac Surg 12 (1943) 548

BAUMGARTEL F und GREMMEL H Die Lungensequestration und ihre klinische Bedeutung Thoraxchirurgie 7 (1960) 547

The only author who disagrees about the value of angiography appears to be WEILAUER, who considers that at aortography the abnormal artery appears to fill poorly or not at all. This view is perhaps based on cases before the present day high technical standards of aortography had been achieved.

In eight cases the aberrant arteries left the aorta supradiaphragmatically and in five cases subdiaphragmatically. In one case there were both supra- and sub-diaphragmatic anomalous arteries to the sequestrum but, which is rare, only from branches of the aorta, i.e. the coeliac and intercostal arteries. In a case like this, especially, aortography is important for a correct planning of the surgical intervention.

Most authors are of the opinion that one or several aberrant vessels are always present in pulmonary sequestration. SCHUSTER & HUZLY, among other writers, denied the essential importance of aberrant vessels but admitted that they are usually encountered. These authors described three cases with aberrant arteries but without sequestration, at operations for carcinoma, tuberculosis and bronchiectasis.

Obviously, the main obstacle to achieving unanimity in classification of borderline cases is the wealth of possible variation in anomalies in general and not least in lung anomalies. The case reported by TUSONIE & MOLNAR (1966) with six distinct anomalies in the thoracic cavity and two apparently secondary abnormalities is a characteristic example. It is probably not possible to compress all the different forms of occurrence into the classifications that have been presented. The majority can be separated into groups meeting certain requirements. They are sequestrations in a pure form, to quote SMITH, although obviously many transitional forms must be taken into account.

The last two case reports (Cases 15 and 16) are typical borderline cases and constitute examples of the difficulty of classifying pulmonary lesions that are supplied by systemic arteries but have an open connection to the bronchial tree. They thus do not involve sequestration in accordance with the basic definition given at the beginning of this paper. The first case concerned a highly anomalous lung supplied by a number of aberrant arteries. The second case was one of a limited cystic ectatic section of lung with systemic arterial supply and sequestrum-like appearances at microscopy (cf. BRUCK 1954-55).

The present material affords some indication of the method of procedure in the diagnosis of sequestrum-like masses. A pneumomediastinum can in principle, in the same way as a pneumoperitoneum, reveal or at least suggest an aberrant vascular connection to the pulmonary expansivity from the thoracic aorta (Fig. 1). Both methods must however be regarded as primarily indirect and cannot compete with angiography for yielding accurate information.

Although the area from which the cases were admitted to the Thoracic Surgery

TOSATTI E and GRAVEL J A Two cases of bronchogenic cyst associated with anomalous arteries from the thoracic aorta Thorax 6 (1951) 82
TURK L N and LINDSKOG G E The importance of angiographic diagnosis in intralobar pulmonary sequestration J thorac cardiovasc Surg 41 (1961) 299
TURUNEN M and HARJOLA P Intralobar sequestration of the lung Ann Chir Gynaec Fenn 46 (1957) 451
WELLAUER J Die Lungensequestration und die Herzzwerchfellwinkel Radiologe 2 (1962) 74
WYMAN S M and EYLER W R Anomalous pulmonary artery from the aorta associated with intrapulmonary cysts (Intralobar sequestration of lung) Radiology 59 (1952) 658

BESKIN C A and BATON R A Intralobar enteric sequestration of lung containing aberrent pancreas J thorac cardiovasc Surg 41 (1961) 314

BRUCK H Doppelseitige abnorme Arterienverhältnisse bei einem Fall von bilateraler Lungen cyste Thoraxchirurgie 2 (1954/1955), 192

BRUNNER S A Intralobar bronchopulmonal sequestration Nord Med 60 (1958) 1207

FUSONIE D and MOLNAR W Anomalous pulmonary venous return pulmonary sequestration bronchial atresia aplastic right upper lobe pericardial defect and intrathoracic kidney Amer J Roentgenol 97 (1966) 350

GALLAGHER P G, LYNCH J P and CHRISTIAN H J Intralobar bronchopulmonary sequestration of the lung Report of two cases and review of the literature New Engl J Med 257 (1957) 643

HARRIS H A and LEWIS I Anomalies of the lungs with special reference to the danger of abnormal vessels in lobectomy J thorac Surg 9 (1940) 666

HEIKEL P E and PASILA M Intralobar sequestration of the lung Progr pediat Radiol 1 (1967) 256

HILL M C MUTO C N MANI J R and DOZIER W E The value of pneumoperitoneum in diagnosis of sequestered lung Amer J Roentgenol 91 (1964) 291

JENSEN V and WOLFF A *Congenital intralobar pulmonary sequestration with anomalous* artery from the aorta Acta radiol 45 (1956) 357

KENNEY L J and EYLER W R Preoperative diagnosis of sequestration of the lung by aortography J Amer med Ass 160 (1956) 1464

KILMAN J W BATTERSBY J S TAYBI H and VELIOS F Pulmonary sequestration Arch Surg 90 (1965) 648

KYLLONEN K E J *Intralobar pulmonary sequestration Ann Chir Gynaec Fenn 52 (1963)* 17

MARTINY J Bronchopulmonal sequestration Nord Med *61 (1959)* 500

NIELSEN P B Intralobar bronchopulmonary sequestration Amer J Roentgenol 92 (1964) 547

PAPILLON J JAUBERT DE BEAUJEU M PINET F et coll Intérêt de l angiocardiographie dans les malformations pulmonaires J *Radiol Électrol 38 (1957) 602*

PRYCE D M Low accessory pulmonary artery with intralobar sequestration of the lung a report of seven cases J Path Bact 58 (1946) 457

RANNIGER K and VALVASSORI G E Angiographic diagnosis of intralobar pulmonary sequestration Amer J Roentgenol 92 (1964) 540

REKTORZIK E Quoted by BAUMGARTEL & GREMMEL

RIBAUDO C A ROSSI P and COMER J V Intralobar bronchopulmonary sequestration demonstrated by aortography and selective arteriography of the anomalous vessel Ann intern Med 64 (1966) 381

ROKITANSKY C Quoted by BAUMGARTEL & GREMMEL

ROUAN M BARROUX P and CAMAIN R Sequestration pulmonaire diagnostiquée par la tomographie Presse méd 66 (1958) 1879

RUBIN E H RUBIN M ATTAI L and HEIMANN W G Intralobar pulmonary sequestration aortographic demonstration Dis Chest 50 (1966) 561

SCHUSTER G und HUZLY A Lungensequestrationen Nebenlungen und aberrierende Gefasse *Fortschr Rontgenstr 100 (1964) 39*

SMITH R A A theory of the origin of intralobar sequestration of the lung Thorax 11 (1956) 10

SPENCER H Pathology of the lung Pergamon Press *Oxford 1962*

samples (10 ml) were taken at regular intervals (Fig 1) The serum concentration of papaverine was estimated photometrically using the method described by AXELROD et coll (1958) which is a specific one and sensitive to papaverine in biologic materials The blood pressure (systolic and diastolic) was measured with a blood pressure cuff (for description see WRIGHT 1952) ECG (one chest lead) was employed to register heart rate and rhythm Salivation and the near point of the power of accomodation were measured according to the procedures described by MOLLER & ROSEN (1968) Six healthy volunteers three women and three men aged 22—28 years were subjected to all these examinations

II The effect of oral doses of papaverine on the gastric emptying rate was estimated by the isotope method described by BROMSTER et coll (1968) The elimination from the stomach of an iodine isotope RIHSA incorporated into a liquid test meal was followed by external counting with a gamma scintillation detector The changes of the gastric contents with regard to pH and osmolarity were determined in samples taken simultaneously with the external counting The hydrochloric acid secretion was estimated (BROMSTER 1969) five healthy volunteers two women and three men aged 20—27 years being included in this study

III The effect of papaverine given orally on the gastric emptying rate and the small bowel transit time was followed by roentgen studies (barium contrast medium) in six healthy volunteers two women and four men aged 17—30 years. To ensure that standard conditions prevailed in the roentgen examinations these were carried out with the subject in prone position after the administration of 300 ml Mixobar ® S G 3 0 (Kistner Sweden) Roentgenograms were obtained immediately after intake of the barium meal and subsequently 5 10 15 30 45, 75 and 105 minutes later The subjects remained in the same position throughout the examination

The subjects fasted from the night before in all the examinations relating to orally given papaverine These in the isotope and roentgen studies were carried out with double blind technique The tablets were given one hour before administration of the test meal or the contrast medium

IV To investigate the influence of gastric secretion and acidity on the appearance of the contrast medium initiated by the roentgenologic observations the following tests were performed

1 The barium meal was mixed with gastric juice from patients after augmented histamine stimulation (KAY 1953) in ratios of from 1 0 2 up to 1 1

2 The barium meal was mixed with buffer solutions of pH values 2 2 3 0 4 0 5 0 6 0 and 7 0 in proportions 1 1

3 The barium meal was mixed with gastric juice from subjects who had

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EFFECTS OF PAPAVERINE ON GASTRIC EMPTYING AND GASTRIC SECRETION IN MAN

by

D. BROMSTER, E. LINDGREN, A. ROSEN and M. THEORELL

The main part of the documentation on the spasmolytic effect of papaverine on the gastrointestinal tract is fairly old and contradictory (HOLZKNECHT & SGALITZER 1913, DANIELOPOLU et coll. 1924, GOTTE 1934, GAGLIO & BLASI 1965). A study of the effect of papaverine on the gastric emptying rate in man has therefore been included in a series of investigations of anticholinergic agents (BROMSTER et coll. 1969). In the present investigation also roentgen examinations have been used for studying the effect of papaverine on the gastric emptying rate and the small bowel transit time; the serum concentration of papaverine was determined for the doses used.

Methods and Material

The investigation was divided into four parts I—IV.

I. The serum concentration after oral and intravenous administration of papaverine, and the effect of orally administered papaverine on blood pressure, salivation, power of accommodation, and heart rate, were studied. Venous blood

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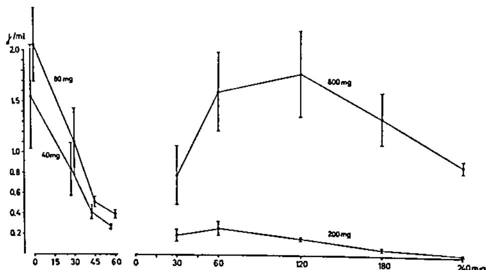


Fig 1 Serum concentrations of papaver ne (/ml) after intravenous administration of 40 mg and 80 mg doses and after o al administration of 200 mg and 800 mg doses (means ± S D) in six healthy s bjects

subjects (K A P L and I S) The remaining two subjects however had a quicker emptying after the 200 mg dose of papaverine and in one of these (R S) the difference in comparison with placebo was almost significant ($p<0\ 05$) One of the subjects was examined after an 800 mg dose and then had lower emptying

The starting index (S I) was on an average lower after the 200 mg dose than after placebo (see Table) indicating an initially quicker emptying Following the 800 mg dose S I was the same as after placebo

No significant effect could be shown on the pH and osmolarity of the gastric contents or on the hydrochloric acid secretion (see Table)

Roentgen studies of the gastric emptying also showed varying effects in the different subjects In all of them however the initial emptying was more rapid after papaverine than after placebo Two of three subjects had on the whole a slower emptying after the 200 mg dose of papaverine the emptying was rapid initially but thereafter slowed down so that after 7ɔ minutes a larger amount of the barium contrast medium remained in the stomach than at the same time after placebo The same pattern was found in two of the three subjects receiving the 800 mg dose of papaverine (see Fig 2)

A varying effect was also observed on the small bowel transit time In the two subjects who on the whole had accelerated gastric emptying the small bowel

received a 200 mg oral dose of papaverine one hour before the collation of gastric juice was begun Samples were taken of the gastric juice at the first, second and third half hours The ratios were 1 1 and 1 2

4 Papaverine in a final concentration of 25 γ/ml was added to the mixtures described in (1) and (2) above

Roentgenograms of the test tubes containing the various mixtures (1) to (4) were obtained at the same intervals after admixture of the barium contrast medium as in the roentgen examinations (III)

In the isotope studies, the gastric emptying curves were derived according to HUNT & SPURRELL (1951)

The half life of the meal, T 1 2, was the measure of the gastric emptying rate, and the starting index, S I, was taken as the time at which emptying seemed to begin

With regard to the roentgen studies, a blind evaluation of the emptying rate was made by an estimation of the amount of barium contrast medium remaining in the stomach at 5, 30 and 75 minutes

The drugs used were 40 mg tablets of papaverine (Papaverin ACO, Sweden) and an injection solution of papaverine (40 mg/ml) (Papaverin ACO, Sweden) 15 mg tablets of propantheline bromide (Pro Banthine, Searle), and placebo tablets containing lactose but having the same appearance as the papaverine tablets

In the roentgen studies three subjects were given the 200 mg dose (B J I L and L O) and three subjects the 800 mg dose of papaverine (J B U G and B T)

Results

Papaverine in an amount of 200 mg administered orally gave a detectable serum concentration, and 2 hours after an oral 800 mg dose the serum concentration was approximately equal to the concentration observed some 15 minutes after the intravenous administration of 40 mg and 80 mg of the drug (Fig 1)

No effect on salivation, power of accommodation, or heart rate could be shown nor were blood pressure or heart rhythm (ECG) affected Drowsiness and sometimes superficial sleep occurred after the large doses

The results of the isotope studies are shown in the Table, giving the gastric emptying rate, T 1/2, the starting index, S I the pH and osmolarity of the gastric contents at 2 hours, as well as the estimated amounts of hydrochloric acid secreted by 2 hours Papaverine increased the half life of the meal but the difference in comparison with the placebo effect was too small to be significant After the small dose, a distinct, but not significant, increase was observed in three

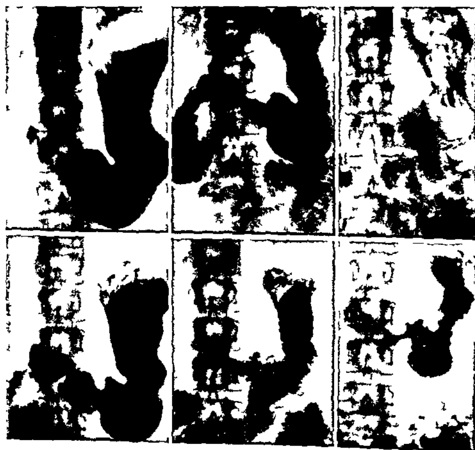


Fig 2 Roentgenograms obtained 5 30 and 75 minutes after administration of the barium contrast medium The upper row refers to placebo and the lower row to 800 mg papaverine dose given to the subject one hour before the barium contrast

gastric juice or with buffer solutions no flocculence could be seen in the roentgenograms Papaverine was present in the gastric juice from a person who had taken papaverine orally in amounts of 22 γ/ml on the first 11 γ/ml on the second and 3 ml on the third half hour When papaverine was added to the mixtures of barium meal and histamine induced gastric juice or buffer solutions in a concentration of 25 ml no change in appearance of the barium meal could be observed in the roentgenograms Experiments involving non stimulated gastric juice showed a similar but not so obvious a change in the barium contrast medium

Table

Isotope studies of the gastric emptying rate at different doses (P indicates placebo) with reference to the half life of the meal ($T_{1/2}$), starting index (S I), pH and osmolarity of the gastric contents at 2 hours and the hydrochloric acid secretion by 2 hours (means and S D)

Subject	$T_{1/2}$ (minutes)			S I (minutes)			pH values			Osmolarity (mOsmol/l)		
	P	200 mg	800 mg	P	200 mg	800 mg	P	200 mg	800 mg	P	200 mg	800 mg
K A	22	33	27	18	9	30	2 15	2 00	2 40	241	360	276
H G	27	17	58	26	33	34	3 10	1 60	3 50	185	187	267
I I	58	92	50	19	−10	16	3 45	3 25	2 25	346	354	292
I S	42	81	45	37	−11	13	2 50	1 60	1 60	287	219	230
R S	41	29	—	−4	24	—	2 00	2 20	—	193	303	—
Mean	38	50	45	19	8	23	2 6	2 1	2 4	250	285	266
S D	14	34	13	15	21	10	0 6	0 7	0 8	67	79	26

Acid secretion by 2 hours (mean ± SD) placebo experiments — 31 1 ± 6 7 mEq 200 mg papaverine — 41 5 ± 10 7 mEq 800 mg papaverine — 40 5 ± 15 7 mEq

transit time as well was shorter than after placebo After the 200 mg dose in one subject (L L), the barium agent was present even in the right colon after only 30 minutes (see Fig 3, in which the left colon is filled with contrast medium at 75 minutes), while after the 800 mg dose in another subject (J B) the medium was seen in the right colon already after 10 minutes

Two subjects (U G and B T) were examined on a third occasion, when they had been given an oral dose of 120 mg propantheline 2 hours previously This time, they both had an extremely retarded gastric emptying, with the main portion of the barium remaining in the stomach after 75 minutes or more (Fig 4)

The serum concentration of papaverine was also determined in these six subjects The values were approximately of the same magnitude as those in the other group of six subjects (cf Fig 1)

In the papaverine experiments but not in those with placebo and propantheline, the barium contrast medium in the stomach had a granular and flocculent appearance in the roentgenograms this phenomenon occurred after half an hour In vitro studies showed that this change in appearance could be reproduced if the barium meal was mixed with gastric juice from a person who had taken an oral 200 mg dose of papaverine an hour prior to the collection of the gastric juice Two such experiments with gastric juice from two different subjects gave the same result (Fig 5) When the barium meal was mixed with histamine induced



Fig 4 Roentgenograms obtained 5 and 75 minutes after administration of the barium contrast medium. An oral dose of 120 mg propantheline was given to the subject 2 hours before the barium contrast (cf fig 2)

and heart rate was observed nor has it been claimed that papaverine has anti cholinenergic properties The doses used in this investigation had no such effects on the circulation of a magnitude sufficient to affect blood pressure or heart rhythm This observation confirms earlier findings (for reference, see REYNOLDS & RANDALL 1957) The roentgenograms in all the subjects, displayed a change in appearance of the barium contrast medium it became flocculent both after the 200 mg and the 800 mg doses of papaverine Neither placebo nor propantheline produced such a change In vitro studies showed that non stimulated gastric juice caused a similar change in appearance The alteration was however most obvious in experiments involving gastric juice aspirated after papaverine administration Papaverine as such did not produce any change in the barium meal nor was the acid concentration as determined in the experiments with buffer solutions of a magnitude to be significant It thus would appear that a relationship exists between the administration of papaverine and the change in the appearance of the barium contrast medium Papaverine possibly causes an increase of some constituent that is normally present in the non stimulated gastric juice This theory will be considered in investigations under way

Relaxation of the muscles of the pyloroduodenal region might explain the initially rapid emptying The antral motility may also be assumed to diminish thus causing a retardation of the gastric emptying The degree of spasmolysis in the different regions might decide the total effect of papaverine on the emptying process Papaverine in this regard differs from anticholinergic agents such as propantheline as the latter causes an immediate and long lasting delay in the emptying BROMSTER et coll 1969) Another explanation of the different emp-

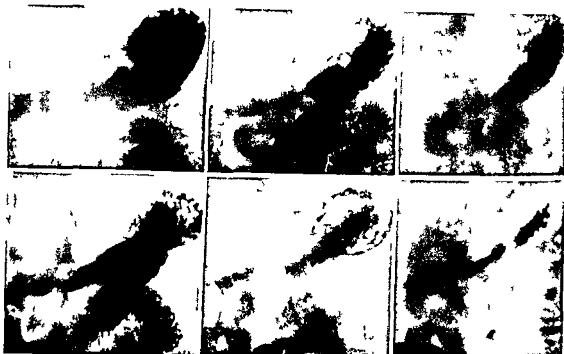


Fig 3 Roentgenograms obtained 5 30 and 75 minutes after administration of the barium contrast medium The upper row refers to placebo and the lower row to 20 mg papaverine doses given to the subject one hour before the barium contrast

Discussion

The most prominent of the effects of papaverine is held to be the diminution of tone of the smooth muscles Some authors (e g GOTTE 1934) have stated that this effect is most marked if spasm occurs in the smooth muscles, as, for example, in pylorospasm, but the reports are contradictory (cf GAGLIO & BLASI 1965) The effect of relaxation is most convincingly documented with regard to contractions of the smooth muscles of blood vessels, as in cerebral angiospasm (RUSSEK & ZOHMAN 1948) The clinical effect of papaverine on spastic conditions of the gastrointestinal tract is generally considered to be relatively weak (REYNOLDS & RANDALL 1957)

Since the difficulties of determining the presence of spasm in the gastrointestinal tract are great it was decided to study the effect in healthy subjects after a test meal or a barium meal In these studies it was consistently found that the gastric emptying rate was initially higher after orally given papaverine, followed by a gradual retardation, so that the total effect in most subjects was a retardation In contrast to the effect of anticholinergics (BROMSTER et coll 1969) the retarding effect of papaverine is slight and insignificant No depression of cholinergic mechanisms, such as gastric secretion, salivation, power of accomodation

Acknowledgements

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SUMMARY

The serum concentration of papaverine was studied after oral administration of 200 and 800 mg and after intravenous administration of 40 and 80 mg of the drug. No effect of the doses on the cholinergic mechanisms was observed. In studies with a test meal containing 131I the oral doses resulted in an initially rapid and subsequently somewhat slower gastric emptying. These two effects could also be demonstrated in roentgen examinations using a barium contrast medium. The barium contrast became flocculent in all the subjects after administration of papaverine, supposedly due to a qualitative alteration of the gastric secretion produced by the drug. In vitro studies supported this hypothesis.

ZUSAMMENFASSUNG

Die Serumkonzentration von Papaverin wurde nach oraler Verabreichung von 200 und 800 mg und nach intravenöser Verabreichung von 40 und 80 mg der Droge studiert. Bei den gegebenen Dosen wurde keine Wirkung auf den cholinergischen Mechanismus observiert. In den Untersuchungen mit Verabreichung einer 131I-haltigen Probemahlzeit und Oraldosen von Papaverin war die Magenentleerung zuerst schnell und dann etwas langsamer. Derselbe Verlauf konnte auch in Röntgenuntersuchungen bei Verwendung eines Bariumkontrastmittels demonstriert werden. Der Bariumkontrast wurde in allen Fällen flockig nach Verabreichung von Papaverin. Wahrscheinlich ist dies einer von der Droge verursachten qualitativen Veränderung der Magensekretion zuzuschreiben. In vitro Studien scheinen diese Hypothese zu unterstützen.

RESUMÉ

La concentration du serum en papaverine a été étudiée après administration orale de 200 et de 800 mg et après administration intraveneuse de 40 et de 80 mg de ce produit. Ces doses furent sans effet sur les mécanismes cholinergiques. Au cours des études faites au moyen d'un repas d'épreuve contenant de l'iode 131, les doses administrées par voie orale provoquent une évacuation gastrique un peu plus rapide au début et un peu lente ensuite. Ces deux effets ont pu être mis en évidence aussi par une étude radiologique faite avec un moyen de contraste baryté. Chez tous les sujets, le contraste baryté est devenu floculant après l'administration de la papaverine; les auteurs supposent que ceci est dû à une modification qualitative de la sécrétion gastrique causée par la papaverine. Les études in vitro ont confirmé cette hypothèse.



Fig. 5. *Roentgenograms* of test tubes containing barium contrast medium (a) and gastric juice from the first half hour collected from a subject one hour after an oral dose of 200 mg *papaverine* (1 : 1 and 1 : 2) (b) gastric juice from the second half hour (1 : 1 and 1 : 2) (c) and buffer solution with pH 3.0 (i.e. the same as the gastric juice) (d). The roentgenograms were obtained one half hour after addition of the barium contrast medium. Mixtures of the barium medium and buffer solutions of different pH or histamine induced gastric juice with or without papaverine had the same appearance as shown in (e).

tying process after papaverine administration has been given by DANIELOPOLU et *coll.* (1924), who initially observed an excitory and subsequently a paralytic phase.

GAGLIO & BLASI (1965) observed no effect on the motility of the duodenum and the small intestine in man after an oral dose of 150 mg papaverine. Thus the smallest effective dose may lie above this level. These authors, however, found constant effects after parenteral doses of 40 mg and 80 mg. Our data indicate that oral doses of 200 mg are inadequate to produce the serum concentration that is obtained after intravenous administration of 40 mg and 80 mg doses of the drug. Therefore, to obtain a satisfactory effect, papaverine should probably be given in oral dose exceeding 200 mg. Roentgen studies indicate, however, that an effect of relaxation can be achieved after 200 mg orally.

The use of papaverine in gastroenterologic praxis, in the hitherto customary doses (up to 100 mg orally), seems dubious. Even if the effect probably increases with higher dosage, though this has not been definitely settled, well documented anticholinergics should be preferred when a spasmolytic effect is required.

FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN) SERAFIMER LASARETTET, STOCKHOLM SWEDEN

PROJECTION OF CINEROENTGEN FILM BY A TV SYSTEM

by

OVE MATTSSON

Equipment for the presentation of cine film must include variable speed projection as well as reverse or still projection for the study of separate frames Magnification may also sometimes be necessary

Direct projection should be possible without any printing procedure for adaptation of film size immediately after the primary processing and drying any time consuming editing and splicing should be avoided It is desirable that one and the same projector be used for film presentation to small groups as well as to large audiences

Projectors available to date have been either of the editing projector type with small screens mostly suited only for small groups of observers or ordinary 16 mm cine projectors Thus for 35 mm film originals one must accept prints of reduced size The projection speeds of these may be altered at wish Printing always involves considerable loss of detail and sometimes of contrast and last but not least of time

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The contents of this paper were presented at Roentgen Staff Meetings at the University of California San Francisco at the University of Pennsylvania Philadelphia, and at the University of Rochester New York in October and November 1964 Submitted for publication 23 April 1968

REFERENCES

AXELROD J SHOFER, INSCOE J R et coll The fate of papaverine in man and other mammals J Pharmacol 124 (1958) 9

BROMSTER D Gastric emptying rate in gastric and duodenal ulceration To be published in Scand J Gastroenterology

— CARLBERGER G and LUNDH G Measurement of gastric emptying rate using [131]I HSA Scand J Gastroenterology 3 (1968) 641

— — — et coll The effect of some oral anticholinergics on gastric emptying pH and osmolarity in man To be published in Scand J Gastroenterology

DANIELOPOLU D SIMICI D et DIMITRIU C Action de la papavérine sur l estomac de l homme Arch int Pharmacodyn 29 (1924) 171

GAGLIO M e BLASI A Valutazione di effetti farmacodinamici sui movimenti intestinali Azione della papaverina (In Italian) Soc Ital Biol sper 41 (1965) 105

GOTTE P Erfahrungen mit dem Spasmolytikum Papavydrin bei intravenoser Anwendung Dtsch med Wschr 60 (1934) 409

HOLZKNECHT G und SGALITZER M Papaverin zur rontgenologischen Differentialdiagnose zwischen Pylorospasmus und Pylorusstenose Munch med Wschr 36 (1913) 1989

HUNT J N and SPURRELL W R The pattern of emptying of the human stomach J Physiol 113 (1951) 157

KAY A W Effect of large doses of histamine on gastric secretion of HCl an augmented histamine test Brit med J 2 (1953) 77

MACHT D I A pharmacologic and clinical study of papaverine Arch intern Med (1916) 786

MOLLER J and ROSEN A Comparative studies on intramuscular and oral effective doses of some anticholinergic drugs Acta med Scand 184 (1968) 201

REYNOLDS A K and RANDALL L O Morphine and allied drug pp 196—210 University of Toronto Press Toronto 1957

RUSSEK H I and ZOHMAN B L Papaverine in cerebral angiospasm (vascular encephalopathy) J Amer med Ass 136 (1948) 930

WRIGHT S Applied physiology Ninth edition p 300 Oxford University Press London 1952

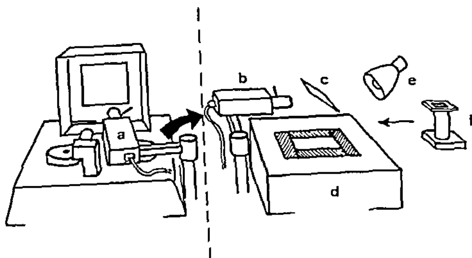
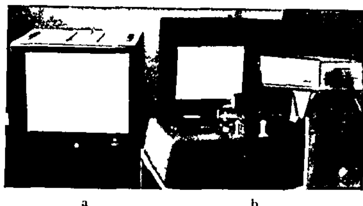


Fig 3 TV camera positioned for cine projection in (a) may be moved over for projection of roentgenograms and the like (b) A mirror (c) is arranged obliquely above the lightbox (d) The overhead light (e) is used for non translucent objects. For slides a small special illuminator (f) may be introduced below the mirror

interval the absence of interval eliminates the risk of interference with the scanning system of the TV camera As the projection image is unshielded a slightly subdued light in the room is an advantage A small control monitor close to the projector facilitates operation especially the electrical adjustments at the same time adjustment of contrast and luminosity so as to compensate for differences in photographic exposure may be made

The projection system is shown in Fig 1 The TV camera to the right is focussed on the projected image appearing on the small sized screen (Fig 1 b) the control monitor is seen to the left in Fig 1 a. In Fig 2 the TV image on the monitor (left) can be compared with the primary image projected by the editing projector (right) Details of the object — in this case an oesophagus — can easily be blown up if desired

Some prefer the negative image for projection thus being similar to the conventional roentgenogram as far as the half tone scale is concerned Others favour the opposite i e a tone scale similar to that in fluoroscopy The left and right sides of a cineroentgenographic film may change in a disturbing way when the projection is changed from a p to p a while sometimes in editing the film is turned over so that focussing troubles are caused Black and white may be interchanged by the action of a switch and left and right may be changed electronically with this equipment A detail analysis which earlier required a magnifica



a b

Fig 1 Projection system (ARNO projector) and TV camera The zoom lens of the camera is focussed on the projected image (b) the control monitor is seen in (a)

Since August 1964 a system of projection of cine film which employs an unconventional principle has been tried in our department This utilizes a closed circuit television installation with a conventional Vidicon tube Several monitors or one large screen TV projector may be used It is not necessary to have the projection system in the lecture room, a permanent installation may serve different rooms, and communication between operator and demonstrator is conveniently established through a two way intercommunication system It is also possible to send the TV image over longer distances by co-axial cable or a video link, certain UHF channels are available for the latter purpose

Briefly described the system is based upon an editing projector, the screen image of which is picked up by a TV camera The basic device is the ARNO projector This, with a rotating prism, gives a continuous projection in which one frame follows the other with a smooth transition without any disturbing dark



Fig 2 Monitor image (left) and original image projected by the editing projector (right) are compared If desired details can be blown up by means of the zoom lens

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DACRYOCYSTOGRAPHY IN OBSTRUCTION OF THE LACRIMAL PASSAGES

by

TRYGVE AAKHUS and BJORN BERGALST

EWING (1909) performed the first dacryocystography with bismuth subnitrate emulsion as contrast medium to demonstrate a lacrimal abscess Most subsequent authors have used oily contrast media such as Lipiodol (BOLLACK 1924) Panthopaque (MILDER & DEMOREST 1954), and Neohydriol (AGARWAL 1961 CAMPBELL 1964 NAHATA 1964 LAW 1967) In recent years water soluble iodinated contrast media have been employed and their advantages have been well documented (RAYNAUD et coll 1964 PRIEGNITZ 1966 HUBER 1966, SARGENT & EBERSOLE 1968) Isopaque 440 (440 mg iodine/ml) is now used for dacryocystography in our hospital

Rapid emptying of low viscous aqueous media from the lacrimal passages may result in poor demonstration of the passages in films obtained after the injection In the present investigation therefore the expoures were made during the injection of contrast medium Twenty two patients with epiphora have been examined with this technique in the course of the last two years A comparison of roentgenologic and clinical findings has been made and is now presented to indicate the value of the examination

From the Departments of Radiology (Director Prof J Frimann Dahl) and Ophthalmology (Director Prof J Ytteborg) Ulleval Hospital Oslo Norway Submitted for publication 28 October 1968

tion of detail in the printing process, may be performed instantly by means of the zoom lens.

The principle described has the advantage of presenting videotape recordings in the same way and in direct connection with other demonstrations in departments with videotape recorders. Switching over the system from camera to recorder is easily made.

The system has also been adapted so as to make possible projection of conventional roentgenograms, tables and illustrations from papers and specimens as well as slides. The same lens and television camera but supplementary close-up lenses and some simple additional equipment will be necessary; a zoom lense of appropriate focal length both for close-ups of detail in magnification and general views of the object may be a useful compromise. The different projection possibilities enable in a few seconds the projection of full size films or diagrams to take place of cinematography. The principle of the projection arrangement is shown in Fig. 3. The TV camera is moved over to another position where it can be focussed on the object, e.g. the roentgenogram, through a mirror positioned obliquely over a horizontal light box. Framing arrangements avoid unnecessary illumination and eliminate loss of contrast through diffuse stray light in the lens system. Reduced size roentgenograms, for instance on 70 mm roll film or 100 mm cut film, may also be projected with the same main equipment and in the same way.

Overhead light is used for the presentation of illustrations on paper, photographic prints, tables, case reports, drawings, scintigrams, as well as of specimens. Arrangements have been made for the projection of slides with the same system. A small illuminator with a frame suited for 2 by 2 inch slides can be connected to the camera lens system.

SUMMARY

A system for projecting cineroentgenographic film is described. This has also been adapted for the demonstration of conventional roentgenograms, tables, illustrations in books, specimens, slides and similar matter.

ZUSAMMENFASSUNG

Ein Apparat zur Projektion von Röntgenkinefilmen wird beschrieben. Der Apparat kann zur Projektion von gewöhnlichen Röntgenfilmen, Tabellen, Buch-Illustrationen, Präparaten, Diapositiven und ähnliches adaptiert werden.

RÉSUMÉ

L'auteur décrit un appareillage pour la projection des films ciné-radiographiques. Cet appareillage a aussi été adapté pour la présentation de radiographies simples, de tableaux, d'illustrations dans des livres, de pièces, de diapositives et d'objets analogues.



F g 3



Fig 4

Fig 3 Short marked stenosis in the upper portion of the duct (→) marked dilatation sup rior to the steno is

Fig 4 On left side marked stenosis in the lower portion of the du t (→) and moderate d lata tion of the duct and sac. On right side occlusion at the neck of the sac and retention of medi m in the dilated sac for several minutes after the injection.

excessive reflux resulting in poor filling the passages were better demonstrated by ob tructing the lower punctum with the dilatator during the injection

The material of 22 patients consisted of 11 males and 11 females ranging between 8 and 73 years of age with epiphora of 2 months to 12 years duration Dacryocystorhinostomia had been performed with unsatisfactory results in two of the patients the lesion was unilateral in nineteen and bilateral in the remaining three patients

Results

The unaffected eye was always examined for comparison a normal dac ryocystogram is presented in Fig 1 The lacrimal passages normally collapsed are distended by the medium during the injection, and their calibre in the roentgenograms therefore depends somewhat on the pressure applied The entire

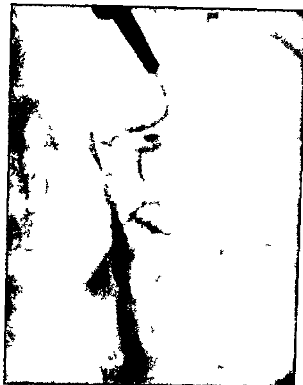


Fig 1

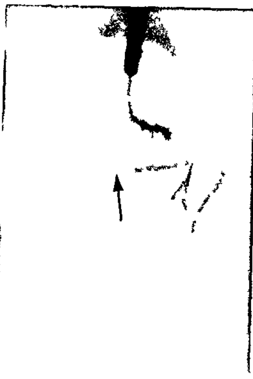


Fig 2

Fig 1 Normal dacryocystogram Injection through the upper canaliculus reflux through the lower canaliculus The normal sac is elongated and joins the duct through a distinct constriction caused by the split fascia of the orbicularis muscle The duct normally appears as a tube of varying calibre with smoothly irregular contours The contrast medium has passed into the nasal cavity

Fig 2 Dacryocystogram of stenosis of the lower lacrimal punctum The lower canaliculus is patent and slight reflux occurred through the narrow punctum (→)

Method and Material The examination was performed on a skull table with the patient supine The films were obtained in an anteroposterior projection with the beam centered on a point near the midline at the level of the infra orbital margin A conventional film was first obtained Following local anesthesia with novesin 0 4 %, the contents of the lacrimal sac were expressed, and the upper lacrimal punctum was dilated with a punctum dilatator A lacrimal cannula was then introduced into the upper canaliculus, exceptionally, the lower canaliculus was injected The contrast medium was introduced under moderate pressure, and the films were produced during the injection Reflux occurred invariably from both canaliculi during the injection, and a swab was therefore gently applied to the closed eye to absorb any excess of contrast medium The swab was removed immediately prior to the exposure In some instances, with

examination had indicated complete obstruction of the duct on the right side and incomplete obstruction of the left duct

In nine patients, dacryocystography revealed complete duct obstruction at various sites and in all of them dilatation above the occlusion was noted Repeat dacryocystography after successful dacryocystorhinostomia in one of these patients showed free passage of contrast medium from the sac to the nasal cavity through a wide communication (Fig 5) No passage of saline had been obtained by syringing in any of these nine patients In seven patients pus was expressed from the sac and in five a palpable mucocele was present

A narrow communication between the sac and the nasal cavity was demonstrated by dacryocystography in two patients following dacryocystorhinostomia The contrast medium passed partly through these communications and partly through narrow natural ducts In both instances a slight passage was obtained by syringing and no pus was expressed from the sacs

Comments

No disagreement between the clinical and the roentgenologic examination was apparent but dacryocystography always provided additional information by demonstrating the exact localization of the obstruction and the state of the passages above the obstruction Against common clinical concepts it was also evident that dilatation of the sac may be present without purulent contents The choice of treatment of lacrimal obstructions may be difficult and undoubtedly dacryocystography aids significantly in arriving at a decision This is particularly important after the introduction of catheter treatment in lacrimal stenoses (HUGGERT 1959 GRIFFITH 1963 HUGGERT & SUNDMARK 1965) Catheter treatment is for example indicated in direct stenoses with shrunken sacs which *often do not* respond well to dacryocystorhinostomia

All the necessary information was usually obtained from the a p films though in a few instances oblique films were taken The superimposition of bone may offer some difficulty in the interpretation However by comparison with the preliminary film it was never really hard to determine the outline of the passages Subtraction films may be useful but are often unsatisfactory due to a slight change in the position of the head between the exposures

Some authors claim better contrast filling of the passages *when the* examination is performed with the patient sitting The present writers have found the procedure easy with the patient in supine *position,* and have secured good contrast filling by taking the films during injection *of the medium* The low viscosity of the contrast medium further facilitates the filling of all passages including narrow stenoses and fistulae Under normal conditions and even



a b

Fig 5 a) *Complete obstruction of upper part of duct marked dilatation above the obstruction* b) Same patient after dacryocystorhinostomia The sac is smaller and a broad communication exists between it and the nasal cavity (→)

length of the passages was usually demonstrated under normal conditions in the films obtained during the injection

Dacryocystography in four patients revealed various canalicular stenoses In one of these, the lover punctum was hardly visible on direct inspection but the films disclosed reflux filling of the lower canaliculus, and slight amounts of contrast medium seemed to have passed the markedly narrow punctum (Fig 2) *Some small amount of saline could be introduced by syringing in one* case only There was no pus in the sacs

Duct stenoses at various points were revealed by dacryocystography in six patients, in two of them bilaterally Degree and length of stenoses, as well as the state of the passages superior to the obstruction, were clearly shown (Fig 3) Marked dilatation had taken place above the obstruction in five of these patients Slight passage of saline was obtained by syringing but only two of the patients had pus in the sac

Marked stenosis in the lower portion of the left duct and complete obstruction at the neck of the right sac were demonstrated in one patient There was moderate dilatation above the obstruction on both sides (Fig 4) The clinical

examination had indicated complete obstruction of the duct on the right side and incomplete obstruction of the left duct

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sometimes in stenosis of the passages, the medium is rapidly emptied after the injection although retention of medium above a marked obstruction for several minutes may occur (cf Fig 4)

Most investigators inject the medium through the lower canaliculus We choose the upper canaliculus to reduce the clinical importance of inadvertent paracanalicular injection, obstructions of the upper canaliculus do not cause epiphora when the lower canaliculus is patent The risk associated with para canalicular injection of water soluble contrast media is however small, as these media are readily absorbed from the tissues This complication seems moreover to be infrequent, and has not been encountered in the present material

SUMMARY

A modified technique of dacryocystography is described The roentgenologic findings in 22 patients with epiphora are presented and compared with the clinical signs The examination is simple and provides detailed information on the site and degree of obstruction as well as on the state of the lacrimal passages above the block

ZUSAMMENFASSUNG

Eine modifizierte Methode zur Ausfuhrung von Dakryocystographie wird beschrieben Die Rontgenbefunde in 22 Epiphora Patienten werden besprochen und mit den klinischen Erscheinungen verglichen Die Untersuchungsmethode ist einfach und gibt genaue Auskunft uber Platz und Grad der Stenose sowie uber den Zustand der Tranenwege oberhalb der Verengerung

RÉSUMÉ

Les auteurs decrivent une technique de dacryocystographie modifiee Chez 22 malades atteints d epiphora ils presentent les resultats de l examen radiographique et les comparent aux signes cliniques L examen est simple et fournit des renseignements detailles sur le siege et le degre de l obstruction ainsi que sur l etat des voies lacrymales au dessus du blocage

REFERENCES

AGARWAL M L Dacryocystography in chronic dacryocystitis Amer J Ophthal 52 (1961) 245

BOLLACK J Sur l exploration radiographique des voies lacrymales par l injection d huile iodée Ann Oculist (Paris) 161 (1924) 321

CAMPBELL W The radiology of the lacrimal system Brit J Radiol 37 (1964) 1

EWING A L Roentgen ray demonstrations of the lacrimal abscess cavity Amer J Ophthal 26 (1909) 1

GRIFFITH T Polyethylene tubes in canaliculus surgery *Brit J Ophthal* 47 (1963) 203

HUBER A Augen *In* Lehrbuch der Rontgendiagnostik Band III Georg Thieme Verlag Stuttgart 1966

HUGGERT A The treatment of stenosis of the lacrimal canaliculi Acta ophthal 37 (1959) 355

— and SUNDMARK E Treatment of lacrimal obstruction Amer J Ophthal 60 (1965) 603

LAW F W Dacryocystography Transl ophthal Soc U K 87 (1967) 395

MILDER B and DEMOREST B H Dacryocystography The normal lacrimal apparatus Arch Ophthal 51 (1954) 180

NAHATA M C Dacryocystography in diseases of the lacrimal sac Amer J Ophthal 58 (1964) 490

PRIEGNITZ F Zur Rontgenkontrastdarstellung der Tranenwege Klin Mbl Augenheilk 148 (1966) 887

RAYNAUD G PERDRIEL G SAIS J et MARTIN H Avantages et inconvénients de la radiocinématographie des voies lacrymales Bull Soc Ophthal Fr 64 (1964) 365

SARGENT E N and EBERSOLE C Dacryocystography The use of sinografin for visualization of the nasolacrimal passages Amer J Roentgenol 102 (1968) 831

FROM THE DEPARTMENT OF NEURORADIOLOGY (DIRECTOR PROF T GREITZ), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

CEREBRAL BLOOD FLOW IN OCCULT HYDROCEPHALUS STUDIED WITH ANGIOGRAPHY AND THE XENON 133 CLEARANCE METHOD

by

T GREITZ

Occult hydrocephalus has received increasing attention during the last few years due to the reversibility of the serious, associated, symptoms, which include dementia and apraxia of gait A vast number of these patients may be rescued by the insertion of an atrioventricular shunt or similar procedure The often dramatic improvements following this relatively simple operation are well known although the nature of the underlying mechanism has not yet been agreed upon Several theories have been offered YAKOVLEV attributed the gait disturbances to stretching of the long paracentral fibres to the lower extremities PENFIELD et coll and KIBLER et coll described periventricular demyelination and suggested a vascular cause BREIC et coll considered a general increase in cerebral blood flow to be the most plausible cause of the clinical improvement following a shunting procedure Few clinical data are available however to support any of these theories

The cerebral circulation may now be studied in two ways with angiography and through recording of the clearance curve by external counting after intra

Submitted for publication 19 November 1968

carotid injection of an inert radioactive freely diffusible gas (LASSEN & INGVAR 1963 INGVAR et coll 1965) These methods have been used in the present work in an attempt to shed some light on the mechanism behind the signs in occult hydrocephalus.

Methods The determination of the cerebral blood flow was carried out by the ^{133}Xe clearance method of LASSEN & INGVAR The regional cerebral blood flow for one cerebral hemisphere usually *the right, was determined in conjunction* with angiography of the internal carotid artery, 500 μCi of ^{133}Xe being injected about ten minutes after the completion of the angiographic examination and the clearance curve obtained with a 3′ crystal detector and a wide angle collimator Calculations were made of the mean cerebral blood flow (CBF_m) from the bi exponential curves by the compartmental method The fast flow (CBF_f) and the slow flow (CBF) components as well as the relative weights of the grey and white matter were also calculated A blood gas analysis with estimation of the arterial carbon dioxide tension was made with the micro-Astrup method in con junction with the cerebral blood flow determination

Cerebral angiography was carried out by percutaneous puncture of the internal carotid artery *The cerebral circulation time* was taken according to the method of GREITZ (1956) as the time interval between the maximal filling of the carotid *siphon and the parietal veins In cases with deformity of the third ventricle* (GREITZ & LOFSTEDT 1954, GREITZ et coll 1967) angiography of the vertebral artery was *performed*

Encephalography was carried out in accordance with the technique described by LINDGREN (1949) Great care was always taken to ensure filling of the basal cisterns and the subarachnoid space over the convexity The hydrocephalic index was determined as proposed by LINDGREN (1951) as the quotient between the greatest width of the anterior horn and the greatest internal width of the skull

Gamma cisternography was performed according to the method described by DI CHIRO (1964) 1 μCi per kg body weight being injected intrathecally after lumbar puncture Scans were made over the head in two planes at 3 6 24, and 48 hours In cases of slow CSF circulation, additional scans were made at 3, 4 and sometimes even at 5 days This method was applied in the majority of cases

In cases treated with an atrioventricular shunting procedure *the intraventric*ular pressure was recorded with electromanometric methods during the operation Simultaneous recording of the lumbar pressure *was made in certain* cases and in other cases the lumbar CSF pressure was measured with an open end manometer

Material The cerebral blood flow was studied in 26 cases with clinical en cephalographic and angiographic evidence of hydrocephalus Seven additional

Table

*Cerebral circulation in 26 cases of hydrocephalus and 7 cases of atrophy Mean values and S D of five parameters related to mean age mean hydrocephalic index and mean pCO Normal values of CCT from Greitz (1968) Normal values of mean cerebral blood flow (CBF_m) and its fast (CBF_f) and slow (CBF_s) components as well as grey matter weight estimates according to Ingvar et coll (1968) *** denotes P value difference in relation to normals less than 0 1 per cent ** denotes P value for this difference less than 1 per cent*

	Number of cases	Age	Index	PCO_2	CCT	CBF_m	CBF_f	% grey matter	CBF_s
Normal					3 43	49 7	79 7	49 2	20 9
					0 51	5 6	10 7	3 9	2 6
Non pressure hydrocephalus									
Ectasia of vertebral artery	9	59	0 35	34	5 42	27 8	54 3	32 0	15 4
					0 86	4 52	8 20	7 75	5 27
					***	***	***	***	**
Non pressure hydrocephalus									
Other types	12	52	0 42	34	4 67	31 3	54 7	40 3	15 1
					0 86	6 38	10 62	6 96	3 99
					***	***	***	***	**
Pressure hydrocephalus	5	31	0 44	36	4 94	33 0	56 6	38 8	17 0
					1 10	4 00	7 83	8 56	2 55
					**	***	***	***	**
Atrophy (controls)	7	58	0 35	37	3 93	41 0	62 1	48 4	20 1
					0 74	4 55	12 35	6 60	4 06
					—	**	**	—	—

cases with clinical and encephalographic evidence of cerebral atrophy served as controls (see Table) Twenty four cases had communicating hydrocephalus and two had obstructive hydrocephalus, in one case caused by aqueduct stenosis and in the other by posterior fossa arachnoiditis Five cases, including the last mentioned two cases, had clinical and encephalographic signs of increased intracranial pressure, two of these had intracranial tumours Twenty one cases were classified clinically as having normal pressure hydrocephalus In this latter category, hydrocephalus was due to trauma in five cases, to subarachnoid haemorrhage in three and to ectasia of the basilar artery in nine cases The cause of hydrocephalus was obscure in four cases

The diagnosis of hydrocephalus could usually be based on the encephalo

graphic findings alone No encephalographic examination was performed in one case of ventricular dilatation following subarachnoid haemorrhage, and the degree of hydrocephalus was estimated by angiography alone In five out of the twenty one cases classified as low pressure hydrocephalus the encephalographic findings were consistent with an incisural block In the remaining fifteen cases similar changes were found as in convexity block hydrocephalus i e absence of air over the convexities but filling of sulci in the interhemispheric and Sylvian fissures (GREITZ & CREPE to be published)

In the 23 cases in which gamma cisternography was performed, 19 with hydrocephalus and 4 with atrophy the findings at this examination supported the diagnosis In fifteen cases with signs of increased CSF pressure partial or complete suboccipital block was demonstrated by RIHSA cisternography Incisural block was confirmed by this method in two instances In five of twelve cases with encephalographic indication of convexity block hydrocephalus a slow but otherwise normal resorption over the convexity was observed, in the remaining cases filling of the interhemispheric and Sylvian fissures occurred but no obvious absorption maximum over the parasagittal frontal and parietal areas was recorded Filling of the lateral ventricles was observed in eight of these twelve cases. Gamma cisternography revealed a normal CSF circulation in four of the seven cases of atrophy The CSF pressure was measured in two of the five cases with clinical signs of increased intracranial pressure, one with a hypothalamic glioma and one with tentorial herniation and found to be slightly increased, i e 31 and 20 mm Hg respectively The CSF pressure was below 20 mm Hg in the twelve cases with low pressure hydrocephalus in which this measurement was obtained The mean CSF pressure in four cases of basilar ectasia was 13 mm Hg in the five cases of posttraumatic hydrocephalus it was 14 mm Hg in one case of old subarachnoid haemorrhage it was 13 mm Hg and in two cases of hydrocephalus of uncertain origin it was 14 and 11 mm Hg respectively

Results

All the circulatory parameters in cases of hydrocephalus were significantly changed to indicate impaired cerebral circulation (compare with the table) Only three cases had a mean flow above 35 ml per 100 g/min No significant differences in the circulatory parameters existed between cases with low pressure hydrocephalus of differing aetiology Nor were these parameters significantly different in cases with increased CSF pressure The average mean flow value was 30 ml per 100 g/min in the non pressure group and 33 ml per 100 g/min in cases with signs of increased pressure The mean cortical flow for all the hydrocephalic cases was 55 and the mean white matter flow was 15 ml per 100 g/min corresponding to a mean flow value of 30 ml per 100 g/min The

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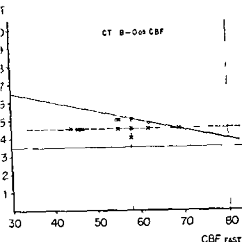


Fig 2 Correlation between the fast component of CBF and the circulation time (CT) as determined by angiography Full horizontal and vertical lines denote mean normal values of the fast component and CT dotted lines indicate 2 S D from the normal values Open circles represent cases with ectasia of the basilar artery crosses indicate cases with other types of hydrocephalus.

angiography and the cerebral blood flow, both with regard to the fast and the mean flow values in hydrocephalus (Figs 2 and 3) The fast flow values were pathologic in fifteen cases and the mean flow values were definitely abnormal in all but three cases The circulation times were only abnormally prolonged in thirteen of the twenty six cases Hence in the individual hydrocephalic case the clearance method is more likely to reveal pathologic changes in the cerebral circulation than is angiography This is in contrast to the findings in cerebrovascular disease in which angiography is more likely to reveal abnormalities in the cerebral circulation as demonstrated by CRONQVIST & GREITZ

Discussion

The fact that in twelve of the twenty six cases of occult hydrocephalus the CSF pressure lay within normal limits indicates that the decrease in cerebral blood flow in hydrocephalus is not necessarily due to continuously elevated pressure At some stage however pressure must be exerted on the ventricular walls to expand the ventricles irrespective of whether this force is back pressure due to retention of the CSF or a combination of this mechanism and transmission of an undamped pulse wave to the ventricular walls from the choroid plexus (BERING 1958 WILSON & BERTRAM 1967) or from an elongated basilar artery (BRIEG et coll EKBOM et coll) As pointed out by HAKIM & ADAMS (1959) the total expansible force is a product of pressure times ventricular surface area. This means that compression of the brain resulting from ventricular enlargement

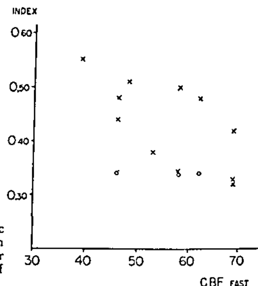


Fig 1 Correlation between the hydrocephalic index and the fast component of CBF Open circles represent cases with ectasia of the basilar artery crosses indicate cases with other types of hydrocephalus

relative weight of the grey matter was 38 per cent Cases with ectatic arteries had the lowest mean flow value, average 28 ml, and a mean relative weight of the grey matter of 32 per cent They differed significantly with regard to these two parameters from normal cases and cases of atrophy

Cases of cerebral atrophy, three of which had presenile dementia, seemed to constitute a heterogenous group as has been pointed out by CRONQVIST et coll Although the degree of ventricular dilatation was about the same as with cases of ectasia of the basilar artery, the cerebral circulation was less impaired with regard to circulation time, mean flow and grey matter weight The mean cerebral blood flow in cases of atrophy was 41 ml per 100 g/min and the mean cortical flow value was 62 ml per 100 g/min, only these values differed significantly from the corresponding values in normal individuals

No obvious correlation existed between the degree of hydrocephalus and cerebral blood flow in cases of basilar artery ectasia (Fig 1) However, in two of these cases, definite clinical improvement followed the operation with an atrioventricular shunt, which indicates a hydrocephalus component in the ventricular enlargement The hydrocephalic index in the remaining sixteen cases was fairly well correlated to the decrease in cerebral blood flow, and there was no difference in this respect between cases with normal pressure and those with increased pressure (Fig 1) In the low pressure group the correlation coefficient was — 0 73 and significant at the 1 % level No such correlation between the degree of ventricular dilatation and cerebral blood flow was apparent in the cases of atrophy

Correlation was found to exist between the circulation time determined by

By the clearance method a decrease in the cerebral blood flow is revealed in all cases of occult hydrocephalus, both of the low and the high pressure type In cases not complicated by vascular changes such as generalized ectasia, this decrease is correlated to the degree of ventricular dilatation which does not seem to be the case in cerebral atrophy

The circulatory disturbances observed in hydrocephalus in the adult are likely to be responsible for the associated serious but reversible symptoms The relationship between cerebral blood flow and ventricular dilatation may therefore help to differentiate at least certain types of cerebral atrophy from hydrocephalus and serve as a guide in the selection of cases for operation

Acknowledgements

This work was sponsored by the Swedish Medical Research Council by the foundation Gustav och Thyra Svenssons Minne and by the Medical Research Council of the Swedish Life Offices.

SUMMARY

The cerebral circulation was studied by angiography and by cerebral blood flow determinations with the xenon 133 clearance method in 26 cases of occult hydrocephalus The flow was reduced even in cases with a normal cerebro spinal fluid pressure The findings in cases of hydrocephalus were compared with normal and cases of cerebral atrophy

ZUSAMMENFASSUNG

Die cerebrale Blutumlaufzeit wurde mittels Angiographie und Bestimmung der cerebralen Durchblutung mit der Xenon 133 Ausscheidungsmethode in 26 Fallen von okkultem Hydrocephalus studiert Der Blutstrom war reduziert auch in Fallen mit Normaldruck der Cerebro spinalflussigkeit Die Befunde bei Hydrocephalus wurden mit Normalfallen und mit Fallen von Gehirnatrophie verglichen

RÉSUMÉ

L auteur a etudie la circulation cerebrale par angiographie et par mesure du debit sanguin cerebral par la methode de clearance du xenon 133 dans 26 cas d hydrocephalie occulte Le debit etait diminué meme dans les cas ou la pression du liquide cephalo-rachidien etait normale Les resultats des cas d hydrocephalie ont eté compares a ceux des sujets normaux et des sujets atteints d atrophie cérebrale

REFERENCES

BERING E A Choroid plexus and arterial pulsation of cerebrospinal fluid Arch Neurol Psychiat. 73 (1955) 165

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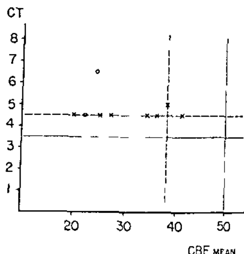


Fig 3 Correlation between the mean cerebral blood flow (CBF) and the circulation time (CT) Full horizontal and vertical lines denote mean normal values of the fast component and CT the dotted lines indicate 2 S D from the normal values Open circles represent cases with ectasia of the basilar artery crosses indicate cases with other types of hydrocephalus

may be maintained at a lower pressure than would be required with normal sized ventricles It is not unlikely that this compression may lead to obstruction of the blood vessels in which the pressure is low, such as veins Furthermore, animal experiments have indicated (BROCK 1968) that even a compression as low as 15 g/cm², applied for a few minutes, may cause a definite and long lasting decrease in the regional cerebral blood flow A less plausible explanation is that the reduction of the blood flow is secondary to a decrease in neuronal activity caused by distension of the brain

Relief of the force or forces causing compression of the brain increase the cerebral blood flow and induce clinical improvement An increase in cerebral blood flow was noted following operation with an atrioventricular shunt in three of the cases with a normal pressure hydrocephalus (The material is as yet too small to allow a more definite conclusion and further results will be published later) Two of these cases had severe generalized arteriectasis affecting all the cerebral arteries, which indicates that circulation disturbances in this condition, which have previously been reported by HULTEN GYLLENSTEN et coll , should not be considered entirely a consequence of the vascular changes unless hydrocephalus can be eliminated

Conclusion

The isotope clearance estimation in hydrocephalus is a more sensitive method for revealing pathologic changes in the cerebral circulation than the circulation time determined by carotid angiography This implies that in the hydrocephalic patient the decrease in flow is due mainly to a reduced cerebral blood volume

By the clearance method, a decrease in the cerebral blood flow is revealed in all cases of occult hydrocephalus, both of the low and the high pressure type In cases not complicated by vascular changes, such as generalized ectasia this decrease is correlated to the degree of ventricular dilatation, which does not seem to be the case in cerebral atrophy

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BREIG A. EKBOM K GREITZ T and KUGELBERG E Hydrocephalus due to elongated basilar artery A new clinicoradiological syndrom Lancet 1967 I p 874

BROCK M Regional cerebral blood flow changes following local brain compression in the cat *In* Cerebral blood flow and cerebrospinal fluid Scand J clin Lab Invest (1968) Suppl No 102

CRONQVIST S and GREITZ T Cerebral circulation time and cerebral blood flow Comparison of angiography and the ^{133}Xe technique Acta radiol Diagnosis 8 (1969) 296

— EKBERG R and INGVAR D H Regional cerebral blood flow related to neuroradiological findings *In* Regional cerebral blood flow p 87 Acta neurol scand (1965) Suppl No 14

DI CHIRO G New radiographic and isotopic procedures in neuroradiological diagnosis J Amer med Ass 188 (1964) 524

— Observations on the circulation of the cerebrospinal fluid Acta radiol Diagnosis 5 (1966) 988

EKBOM K GREITZ T KALMÉR M et coll Cerebrospinal fluid pulsations in occult hydrocephalus due to ectatic basilar artery Acta neurochir 20 (1969) 1

GREITZ T A radiologic study of the brain circulation by rapid serial angiography of the carotid artery Acta radiol (1956) Suppl No 140

— Normal cerebral circulation time as determined by carotid angiography with sodium and methylglucamine diatrizoate Acta radiol Diagnosis 7 (1968) 331

— and GREPE A Encephalography in convexity block hydrocephalus To be published in Acta radiol Diagnosis

— and LOFSTEDT S The relationship between the third ventricle and the basilar artery Acta radiol 42 (1954) 85

— EKBOM K KUGELBERG E and BREIG A Occult hydrocephalus due to ectasia of the basilar artery To be published in Acta radiol Diagnosis

HAKIM S and ADAMS R D The special clinical problems of symptomatic hydrocephalus with normal cerebrospinal fluid pressure J neurol Sci 2 (1965) 307

HULTÉN GYLLENSTEN I L LOFSTEDT S and VON REIS G Observation on generalized arteri ectasis Acta med scand 163 (1959) 125

INGVAR D H CRONQVIST S EKBERG R et coll Normal values of regional cerebral blood flow in man including flow and weight estimates of grey and white matter *In* Regional cerebral blood flow p 72 Acta neurol scand (1965) Suppl No 14

KIBLER R F COUCH R S C and CROMPTON M R Hydrocephalus in the adult following spontaneous subarachnoid haemorrhage Brain 84 (1963) 615

LASSEN N A and INGVAR D H Regional cerebral blood flow measurements in man Arch Neurol 9 (1963) 615

LINDGREN E Some aspects on the technique of encephalography Acta radiol 31 (1949), 161

— Encephalography in cerebral atrophy Acta radiol 35 (1951) 277

PENFIELD W and ELVIDGE A R Hydrocephalus and atrophy of cerebral compression *In* Cytology and cellular pathology of the nervous system Edited by W Penfield P B Hoeber Inc New York 1932

WILSON C B and BERTAM V Interruption of the anterior choroidal artery in experimental hydrocephalus Arch Neurol 17 (1967) 614

YAKOVLEV P I Paraplegias of hydrocephalics Amer J ment Defic 51 (1947) 561

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BACKWARD DISPLACEMENT OF THE UPPER PART OF THE BASILAR ARTERY IN INFANTILE HYDROCEPHALUS

by

E. LA TORRE, E. OCCHIPINTI and A. POLICICITA

The basilar artery follows an intracisternal course, the first part lying in the cisterna pontis and the terminal part in the cisterna interpeduncularis. It usually runs sagittally a few millimeters behind the clivus and joins the posterior cerebral arteries at the level of the posterior clinoid processes. In infancy the basilar artery often lies high in the cisterna interpeduncularis so that the course of the posterior communicating artery from the carotid syphon to the posterior cerebral artery is backwards and upwards (RAIMONDI 1967).

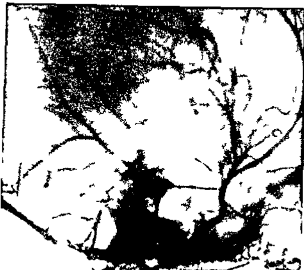
An expanding lesion of the posterior cranial fossa, according to its size and site, may displace the artery laterally, anteriorly or posteriorly. A retrosellar tumour of the third ventricle may also displace the terminal part backwards (SCATLIFF et coll. 1967). An elongated basilar artery, however, usually produces an indentation at the base of the third ventricle (GREITZ & LOFSTEDT 1954, DETTORI et coll. 1966).

Backward displacement of the terminal part of the basilar artery due to dilatation of the third ventricle has also been reported (SCATLIFF et coll. 1967,

Submitted for publication 25 March 1968



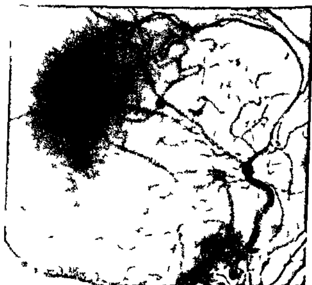
a



b



c



d

Fig. 1. a) Ventriculography head down lateral. Posterior inferior part of third ventricle filled, the floor being herniated into the tentorial notch; no gas passes into the posterior cranial fossa which appears small to judge by the air outlining the lateral ventricle. b) Right retrograde brachial angiography lateral. Marked hydrocephalus; the basilar artery is displaced backwards and the posterior communicating artery is considerably stretched. c) Right retrograde brachial angiography submental view. The posterior cerebral arteries follow an asymmetric course due to traction from the right posterior communicating artery; this artery is absent on the left side. d) Post operative (one month) right retrograde brachial angiography. Normal course of basilar artery but high position of its interpeduncular part; tortuous course of posterior communicating artery which is directed upwards and backwards. These appearances are normal in the infant.


a


b


c


d


e


f

Fig ? Six cases of aqueductal stenosis a) The basilar artery is displaced backwards b) and c) Examples of backwa d displacem nt of the terminal part of the basilar artery wh ch appears flattened by pre sure from the floor of the th rd ventricle d) Lesser degree of backward displacement of the term nal part of ba ilar artery the posterior commr unicat ng artery when inject d always presents a stretched appearance

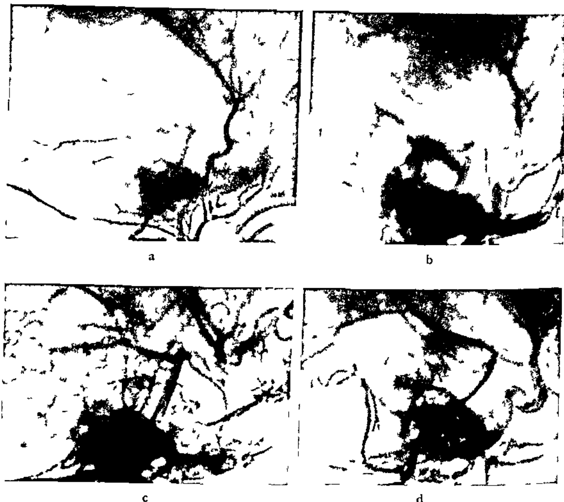


Fig 3 Right retrograde brachial angiography lateral projection in 8 cases of communicating hydrocephalus in which *there was no backward displacement of the terminal segment* of the basilar artery This artery usually runs near the dorsum sellae In four of the cases (a c g h) the posterior communicating artery follows a tortuous course which indicates that the third ventricle is not markedly enlarged

SCHECHTER & ZINGESSER 1967) The close proximity of the floor of the third ventricle to a high terminal part of the basilar artery in children facilitates the angiographic demonstration of dilatation of the third ventricle The following is an illustrative case

Case report

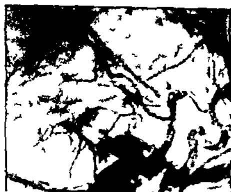
A male infant aged two months was admitted because of increasing size of the skull (in the mother no history of antenatal infection or dystocia) Fontanelles and sutures of the hypertensive type cranial circumference 51 cm



e



g



h

Fig 3 For legend see opposit page

Encephalo ap hy showed the fourth ventricle to be well filled but no gas pa sed upwards through the aquedu t

Ventriculo rap hy dis losed symmetric lateral ventricles *The third* ventricle was much dil t d and its floor had herniated into the anterior part of the tentorial notch no gas passed into the po terior fossa (Fig 1a)

Right retrograde *brachial an i raphy* su gested marked hydrocephalus with backward displacement of the whole basilar artery and *stretching of the* posterior communicating artery (Fig 1b A ubmental iew indicated that the posterior cerebral arteries ran an asymmetric course the ri ht being pulled anteriorly by the stretched posterior communicating art ry which was absent on the left side (Fig 1c)

The infant was discharged with a cranial circumference of 49 cm following a ventriculo venous shunt the pump worked well for a month after which the patient was re admitted for a further an iographic investigation The intracranial vessels now presented almo t normal appearances, this particularly applying to the basilar artery (Fig 1d)

Angiographic findings

Twenty cases of hydrocephalus in infants under 18 months of age were examined Communicating hydrocephalus was diagnosed in 14 cases and aqueductal stenosis in 6 cases, all by lumbar encephalography, these latter cases were also investigated by ventriculography Right retrograde brachial angiography was performed in the whole material Six normal infants acted as controls

The appearances of the terminal part of the basilar artery, the length and appearances of the posterior communicating artery, the distance of the posterior clinoid processes to the basilar artery, as measured along the perpendicular line to the dorsum sellae, were noted in every lateral arteriogram and recorded

The terminal part of the basilar artery presented the same appearances and course in every case of communicating hydrocephalus as in the normal cases (Fig 3) In the case described and in three others of aqueductal stenosis the basilar artery was displaced posteriorly The artery was not obviously displaced in the remaining two cases of aqueductal stenosis (Fig 2)

The length of the posterior communicating artery varied from 3 to 15 mm (average 9 mm) in normal cases, from 8 to 18 mm (average 12 mm) in communicating hydrocephalus and from 12 to 20 mm (average 17 mm) in cases of aqueductal stenosis The artery was sinuous and usually directed postero-superiorly in all normal cases as well as in four cases of communicating hydrocephalus *It was however stretched or had a slight concavity upwards in the* cases of aqueductal stenosis and in those of communicating hydrocephalus

The distance from the posterior clinoid processes to the basilar artery varied from 2 to 10 mm (average 6 mm) in normal cases from 0 to 7 mm (average 4 7 mm) in communicating hydrocephalus and from 3 to 16 mm (average 9 mm) in cases of aqueductal stenosis

Discussion

The dilated third ventricle in the case reported had herniated into the tentorial notch and displaced the basilar artery so that a clivus tumour was suggested The displacement of the basilar artery constituted *the last stage in a condition* that commenced with displacement of only the terminal part The submental view accurately revealed the pressure to which the cerebral peduncles were submitted by the third ventricle and the traction the right posterior communicating artery exercised against this pressure Following relief of intracranial hypertension, the basilar artery previously raised, together with the posterior communicating artery became normal in position

Backward displacement of the terminal part of the basilar artery thus appears to depend upon the width of the third ventricle the length of the interpeduncular part of the artery and the size of the tentorial opening as well as upon a pressure of the supratentorial ventricular fluid greater than that of the fluid in the spaces of the posterior cranial fossa (cf the case of SCHECHTER & ZINGESSER 1967) Stretching of the posterior communicating artery either by dilatation of the lower part of the third ventricle or by antero-superior displacement of the carotid syphon may be an additional factor

The analysis of the angiographic material in normal and hydrocephalic infants has revealed that backward displacement of the terminal part of the basilar artery often occurs in aqueductal stenosis The posterior communicating artery is on the average longer in cases of aqueductal stenosis than in communicating hydrocephalus and longer in both than in normal cases The average distance from the posterior clinoid processes to the basilar artery is less in communicating hydrocephalus and greater in aqueductal stenosis than in normal cases

RAIMONDI (1967) in a report upon 450 infants some of them newborn emphasized that the diagnosis of aqueductal stenosis may be obtained by right lateral retrograde brachial angiography during the venous phase this was based upon antero-inferior displacement of the thalamus flattening of the internal cerebral vein lengthening of the vein of Galen as well as an angle of less than 90 between the latter and the straight sinus

Backward displacement of the terminal part of the basilar artery in infants is a further sign of aqueductal stenosis Although not present in every case, it was always absent in communicating hydrocephalus and in normal cases Its presence is clearly related to supratentorial hypertension with dilatation and herniation of the third ventricle into the cisterna interpeduncularis A low course of the basilar artery into the cisterna interpeduncularis and only a moderate increase of the dimension of the third ventricle are obviously conditions compatible with the absence of this angiographic sign Furthermore a small tentorial notch — the variability of the tentorial opening has been stressed by SUNDERLAND (1958) and CORSELLIS (1958) — hardly allows herniation of the third ventricle without danger to life

A long and stretched posterior communicating artery as well as an increase in the distance from the posterior clinoid processes to the basilar artery seem to constitute additional angiographic features and again are indications of supra tentorial hypertension with subsequent downward and backward displacement of the brain stem This is the opposite to that in the Dandy Walker syndrome in which the basilar artery is displaced upwards against the clivus due to increased pressure in the posterior cranial fossa (FAURE et coll 1963)

SUMMARY

In a material of twenty cases *of infantile hydrocephalus* investigated with pneumography and right retrograde brachial angiography, a backward displacement of the terminal part of the basilar artery was observed *only in* cases of aqueduct stenosis Ventricular supratentorial hypertension which causes herniation of the floor of the third ventricle into the cisterna interpeduncularis is considered the principal factor in the production of this sign

ZUSAMMENFASSUNG

In einem Material von zwanzig Fällen von kindlichem Hydrocephalus die mittels Pneumographie und retrograder Brachialisangiographie untersucht wurden konnte eine Verschiebung nach hinten des distalen Anteiles der *A basilaris nur in Fällen* von Aquaeductstenose festgestellt werden Eine supratentorielle ventrikuläre Hypertension die zur Verschiebung des *Bodens des dritten Ventrikels* in die Cisterna interpeduncularis führt ist als die wesentliche Ursache dieses Zeichens zu betrachten

RÉSUMÉ

Les auteurs ont observé un déplacement vers l'arrière de la partie terminale du tronc basilaire seulement dans les cas de sténose de l'aqueduc sur une série de 20 cas d'hydrocéphalie du nourrisson examinés par pneumographie et par angiographie humérale rétrograde L'hypertension ventriculaire sus tentorielle qui cause une hernie du plancher du troisième ventricule dans la citerne interpédonculaire est la principale cause de ce signe

REFERENCES

CORSELLIS J A N Individual variations in the size of the tentorial opening J Neurol Neurosurg Psychiat 21 (1958) 279

DETTORI P CRISTI G e DALBUONO S Anomalia megadolicobasilare Studio clinico radiologico di 8 casi Radiol med 52 (1966) 1259

FAURE C LEPINTRE J et LYON G Etude radiologique du syndrome de Dandy Walker Acta radiol Diagnosis 1 (1963) 843

GREITZ T and LOFSTEDT S Relationship between third ventricle and basilar artery Acta radiol 42 (1954) 85

RAIMONDI A J Cerebral angiography in the newborn and infant Personal communication (1967)

SCATLIFF J A KIER L ZINGESSER L H and SCHECHTER M M Terminal basilar artery deformity secondary to suprasellar and third ventricular dilatation Amer J Roentgenol 101 (1967) 61

SCHECHTER M M and ZINGESSER L H The radiology of aqueductal stenosis Radiology 88 (1967) 905

SUNDERLAND S The tentorial notch and complications produced by herniations of the brain through that aperture Brit J Surg 45 (1958) 422

TAVERAS J M and WOOD E H Diagnostic neuroradiology p 348 Williams & Wilkins Baltimore 1964

FROM ROENTGEN DEPARTMENT II (DIRECTOR: T. ANDERSSON) REGIONSJUKHUSET, ÖREBRO, SWEDEN

COLLATERAL CIRCULATION BETWEEN BRONCHIAL AND CORONARY ARTERIES

Report on two cases verified by selective catheterization of the bronchial arteries

by

KJELL ÅKE JOHNSSON

The bronchial artery circulation has aroused increasing interest during the last decade. Studies on the vascular supply of malignant tumours (BOIJSEN & ZSIGMOND, VIAMONTE), on bronchiectases (VIAMONTE) and on the altered circulatory conditions in connection with certain congenital defects received most attention at the outset (BJÖRK). It was not until the last three or four years, i.e. when coronary angiography began to be more frequently used, that the bronchial arteries became important as forming part of the collateral circulation in connection with insufficiency of the coronary circulation (ARVIDSSON & MOBERG, BJÖRK).

VON HALLER (1803) and VOSS (1856) demonstrated by post mortem injections that anastomoses exist between the extracardial arteries, i.e. primarily the bronchial arteries and coronary arteries. MOBERG in 1967 demonstrated that connections between the bronchial arteries and the coronary arteries occur in all subjects, regardless of age and thus also independently of atheromatosis. The same author also described anastomoses between the internal mammary arteries

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Fig. 1. Case 1. Coronary angiography. a) Left anterior oblique projection. The anterior descending branch is occluded at its *origin from the aorta*; a small artery is filled farther peripherally; satisfactory filling of a bronchial artery that descended to the region of the atrium was obtained. b) Right anterior oblique *projection*. It is more clearly demonstrated in this projection *that* the anterior descending branch is occluded at its origin; a wide bronchial artery to the area of the atrium is also filled.

and the coronary arteries, though these were much less frequent. The findings were based on post mortem injections. DI GUGLIELMO (1960) was able to demonstrate by thoracic aortography in vivo the existence of anastomoses between the bronchial and the coronary arteries. Coronary angiography subsequently established such connections on several occasions (ARVIDSSON & MOBERG, BJÖRK, PAULIN). On the other hand, it appears that filling of the coronary arteries has not been achieved by catheterization of the bronchial arteries.

Material and Methods. Collateral circulation was established between the bronchial and the coronary arteries by selective catheterization of the former in two patients with angina pectoris. Coronary angiography had preceded the selective investigation in both instances and had been performed under general anesthesia with increase of the intrabronchial pressure by the NORDENSTRÖM method. Two projections at right angles were used, 1 ml Urografin 76 %/kg bodyweight was injected with a Gidlund pressure syringe for each and the Elema Schönander roll film changer with stereo tubes was employed for the



Fig 2 Case 1 Selective bronchial artery catheterization a) Left anterior oblique projection The peripheral parts of the descending branch from the left coronary artery filled via this bronchial artery which had been shown to be wide at coronary angiography b) Right anterior oblique projection The changes are more clearly seen

exposure The selective investigation also in two planes at right angles was carried out under local anesthesia with a red Odman Ledin catheter 6 ml Urografin 60 % were injected by hand for each projection

Case reports

Case 1 Male aged 47 previously healthy with a 2 year history of angina pectoris in connection with effort and improvement on resting had areas of pain band shaped in chest and back, at times radiating into the arms The condition was aggravated by walking during cold weather especially after a meal The patient was of slender build and had no physical signs Laboratory findings were increased blood fat values EKG up to 400 cpm/min at rest and effort Pathologic reactions indicated anterior mural damage

Coronary angiography revealed that the right coronary artery was underdeveloped The left coronary artery was 4 mm wide at its origin the anterior descending branch was completely occluded and the circumflex branch was wider than usual and had an enlarged area of distribution Filling of the bronchial artery was obtained its course being such that it probably participated collaterally in supplying blood to myocardium (Fig 1)

Catheterization of the bronchial arteries disclosed that the anterior descending branch obtained blood from anastomoses between the bronchial and coronary arteries (Fig 2)



a



b



c

Fig 3 Case [illegible] Coronary angiography a) Left anterior oblique projection early phase No contrast filling of the right coronary artery slight *filling of tortuous bronchial arteries descending* towards the atrium b) Right anterior oblique projection The changes are the same as in (a) c) Left anterior oblique projection late phase The right coronary artery *filled via tortuous* bronchial arteries and the sinus node artery

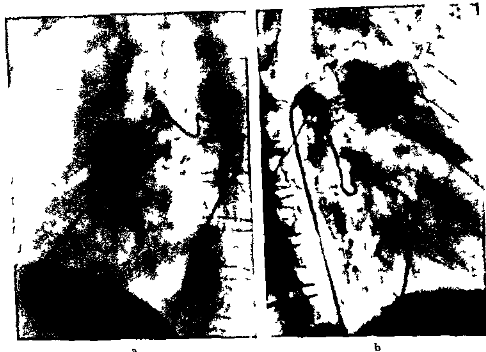


Fig 4 Case 2 Selective bronchial artery catheterization a) Left anterior oblique projection The bronchial artery which coronary angiography had shown to be wide first filled the sinus node artery and then the right coronary artery which was totally occluded at its origin from the aorta b) Right anterior oblique projection The artery makes a characteristic loop around the superior vena cava

Case 2 Female aged 48 with congenital heart disease who had had xanthelasma for eighteen years elevated serum cholesterol for ten and angina pectoris for seven years the latter was aggravated by cold and effort ECG showed distinct lowering of the STT segments on slight effort

Coronary angiography established total occlusion of the right coronary artery near its origin at the aorta Diffuse mural changes were observed in the left coronary artery which however were not completely obliterative Tortuous vessels of fine calibre probably collaterals were filled in the region of the atrium At a late stage in the investigation a bronchial artery supplying the occluded right coronary artery was outlined (Fig 3)

Selective bronchial artery catheterization confirmed the coronary angiography findings (Fig 4)

Discussion

Coronary angiography may indicate that the bronchial arteries run a course that make them satisfactory as collaterals in the event of insufficiency in the blood supply to the myocardium Selective catheterization of these arteries should

then be performed for a definite demonstration of connections between the two vascular areas and for obtaining an idea of the appearance and scope of the collateral circulation

As NORDENSTRÖM has pointed out, it is difficult to fill bronchial arteries by ordinary thoracic aortography owing to the discrepancy in width between the lumina of the aorta and the fine calibre bronchial arteries, in connection with differences in flow Balloon occlusion of the aorta at the level of, or just above, the diaphragm has however enabled satisfactory filling of both the bronchial and intercostal arteries to be obtained

PAULIN, and BJORK, have demonstrated, in large materials, that good contrast filling of the bronchial arteries may be obtained when ECG and coronary angiography indicate myocardial ischemia BJORK obtained satisfactory filling in 53 out of 109 patients with stenosing coronary vascular changes In 91 patients without coronary sclerosis, a corresponding contrast filling was obtained in only 20 patients It therefore seems that myocardial ischemia may be a factor that contributes to maximal utilization of existing coronary vascular anastomoses both extracardial and intercoronary The accumulation of contrast medium in the myocardium during the capillary phase may be an expression of this phenomenon, as first pointed out by NORDENSTRÖM

According to BJORK the technique in coronary angiography is of importance and he gave 0 5 mg nitroglycerine sublingually immediately before injection of the contrast medium Personally, I consider that the increase in intrabronchial pressure, with attendant retarded circulation, created favourable preconditions for satisfactory filling of the bronchial arteries

Anastomosis between the coronary arteries and the bronchial arteries usually takes place at the level of the atrium (MOBERG) This was demonstrated very *clearly in one of the cases now reported and occurred via the sinus node artery* It was not possible to trace with certainty the anastomosis in the other case It is probable, however, that it took place via connections between the bronchial arteries and the fine coronary vascular ramifications at the level of the ventricle the existence of such connections was demonstrated by MOBERG in post mortem injection experiments

The spinal cord is supplied in part by the bronchial and the mediastinal arteries It is therefore important to bear in mind that risks of damage may be run as a result of injecting large doses of contrast medium when working in this vascular region It is essentially the length of time that the medium is in contact with tissue that may cause injury of this kind to occur (HAVERLING) Since, as previously pointed out, there is only little circulation in the vascular area in question, it is important to limit the amount of contrast medium employed to between 6 and 8 ml

SUMMARY

Selective bronchial artery catheterization enabled anastomoses between the bronchial and coronary arteries to be demonstrated in two patients with angina pectoris. The indications, technique and risks of the procedure are discussed.

ZUSAMMENFASSUNG

Anastomosen zwischen den Bronchialarterie und den Coronararterien konnten mittels selektiver Katheterisierung der Bronchialarterie in zwei Patienten mit Angina pectoris angiographisch festgestellt werden. Indikationen, Technik und Risiko des Verfahrens werden diskutiert.

RESUMÉ

Le cathetérisme selectif des arteres bronchiques a permis de mettre en evidence chez deux malades atteints d'angine de poitrine des anastomoses entre les arteres bronchiques et les arteres coronaires. L'auteur examine les indications, la technique et les dangers de cette methode.

REFERENCES

ARVIDSSON H. and MOBERG A.: Extracardiac anastomoses to the myocardium. An angiographic and anatomic study. Acta radiol. Diagnosis 4 (1966) 385.

BJORK L.: Anastomoses between the coronary and bronchial arteries. Acta radiol. Diagnosis 4 (1966) 93.

— Angiographic demonstration of extracardial anastomoses to the coronary arteries. Radiology 87 (1966) 274.

BOIJSEN E. and ZSIGMOND M.: Selective angiography of bronchial and intercostal arteries. Acta radiol. Diagnosis 3 (1965) 513.

DI GUGLIELMO L.: Angiografia coronaria. Volume primo, p. 303. XXI Congresso Nazionale de Radiologica Medica e Medicina Nucleare Atti. Bologna 1960.

HAVERLING M.: Renal phlebography. An experimental study in the pig. Acta radiol. (1966) Suppl. No. 251.

MOBERG A.: Extracardiac anastomoses to the myocardium. Acta radiol. Diagnosis 4 (1966) 385.

— Anastomoses between extracardiac vessels and coronary arteries. I. Via bronchial arteries. II. Via internal mammary arteries. Acta radiol. Diagnosis 6 (1967) 177, 263.

— Anastomoses between extracardiac vessels and coronary arteries. III. Microangiographic appearance. Acta radiol. Diagnosis 7 (1968) 33.

— Anastomoses between extracardiac vessels and coronary arteries. Acta med. scand. (1968) Suppl. No. 485.

NORDENSTRÖM B.: Contrast examination of the cardiovascular system during increased intrabronchial pressure. Acta radiol. (1960) Suppl. No. 200.

— Methods of altering circulatory dynamics to improve roentgen examination of the cardiovascular system. Amer. J. Roentgenol. 89 (1963) 233.

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FROM THE DEPARTMENTS OF PATHOLOGY AND THORACIC RADIOLOGY KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

PRIMARY MALIGNANT LYMPHOMA OF THE LUNG

by

S E DAHLGREN and C O OVENFORS

Malignant lymphoma, confined to a single organ is a rare disease Primary lymphomatous lesions most commonly involve the stomach or the intestine (MCSWAIN & BEAL 1944 and THORBJARNARSON et coll 1956) Primary sites of lymphomatous lesions may however be present in the lungs and about 100 cases have been reported (SALTZSTEIN 1963) Most of the lesions were lymphocytic lymphomas (about 60 %) but cases of Hodgkin s disease and reticulum cell sarcoma in the lungs have been encountered (BECK & REGANIS 1951, AHREN & ZETTERGREN 1963)

Primary lymphomas with the exception of Hodgkin s disease of the lung remain restricted to the lungs and grow very slowly Wide spread dissemination throughout the reticuloendothelial system from a primary lymphoma of the lung of this type has not been reported On the other hand, secondary pulmonary involvement is not unusual in cases of disseminated malignant lymphomas ROBBINS (1953) found evidence of spread of malignant lymphomas to the lungs in 25 % of autopsies in such cases.

The diagnosis of primary pulmonary lymphoma is based on roentgenographic examination and the histologic characteristics of the lesions The roentgenologic features of primary pulmonary lymphomas have been described by ROBBINS (1953) VAN HAZEL & JENSIK (1956) and STERNBERG et coll (1959)

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— Percutaneous balloon occlusion of the aorta Acta radiol Diagnosis 4 (1966) 365
— Selective catheterization and angiography of bronchial arteries in dog Acta radiol Diagnosis 4 (1966) 513
— Selective catheterization and angiography of bronchial and mediastinal arteries in man Acta radiol Diagnosis 6 (1967) 13
— OVENFORS C O and TORNELL G Myocardiography and demonstration of the cardiac veins in coronary angiography Acta radiol 57 (1962), 11
PAULIN S Coronary angiography A technical anatomical and clinical study Acta radiol (1964) Suppl No 233
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a b

c

Fig. Chest films from June 1966. The infiltration has grown to 6.5 cm × 5 cm × 3 cm and now reaches the interlobal fissure; no pleural effusion. Four thin walled cavities are present; no intracavitary fluid and no atelectases.

The red blood cell count was 3.5 mill./mm³ and the hemoglobin 12.7 g %. The white blood cell count was 4,400/mm³ with 62 % neutrophils, 3.5 % eosinophils, 1.5 % basophils, 28 % lymphocytes and 5 % monocytes. The serum creatinine was 1.0 mg %. Electrophoresis gave normal amounts of albumin and globulins. The electrocardiogram was normal and spirometry presented normal values.

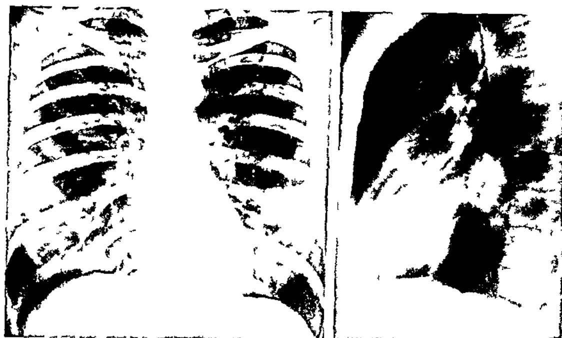


Fig 1 Chest films from November 1956 Rounded poorly delineated infiltration in left lower lobe measuring 3 5 cm × 3 4 cm × 3 5 cm

Primary pulmonary lymphomas, being usually asymptomatic in the early stages are generally detected by routine roentgen examination of the lungs The main differential diagnosis is bronchogenic carcinoma and as the prognosis in primary pulmonary lymphoma is so much better than in disseminated lymphoma or bronchogenic carcinoma it is important for the clinician to be aware of this type of tumor For this reason a case of primary pulmonary lymphoma at first mistaken for bronchogenic carcinoma is reported

Case report

A woman aged 55 had at roentgen examination ten years previously an infiltrate measuring 5 5 cm × 3 5 cm × 3 cm in the left lower pulmonary lobe (Fig 1) Control examinations 2 and 4 months later disclosed no change and the infiltrate was considered to be inflammatory

The present roentgen examination revealed that the lesion had increased in size to an average diameter of 5 cm and cystic degeneration of part of it had occurred (Fig 2) The patient was completely asymptomatic Displacement of the bronchi around the area was demonstrated at bronchography No bronchial occlusion and no communications to the cavities were observed The bronchial walls in the immediate vicinity were somewhat irregular (Fig 3)

No enlarged lymph nodes were present and the blood sedimentation rate was normal



Fig 2 Chest films from June 1966 The infiltration has grown to 6 5 cm × 5 cm × 3 cm and now reaches the interlobal fissure no pleural effusion Four thin walled cavities are present no intracavitary fluid and no atelectases.

The red blood cell count was 3 5 mill /mm³ and the hemoglobin 12 7 g % The white blood cell count was 4 400/mm³ with 62 % neutrophils 3 5 % eosinophils 1 5 % basophils 28 % lymphocytes and 5 % monocytes The serum creatinine was 1 0 mg % Electrophoresis gave normal amounts of albumin and globulins The electrocardiogram was normal and spirometry presented normal values



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The red blood cell count was 3.5 mill./mm^3 and the hemoglobin 12.7 g%. The white blood cell count was 4400/mm^3 with 6? % neutrophils 3.5 % eosinophils 1.5 % basophils ?8 % lymphocytes and 5 % monocytes The serum creatinine was 1.0 mg%. Electrophoresis gave normal amounts of albumin and globulins The electrocardiogram was normal and spirometry presented normal values

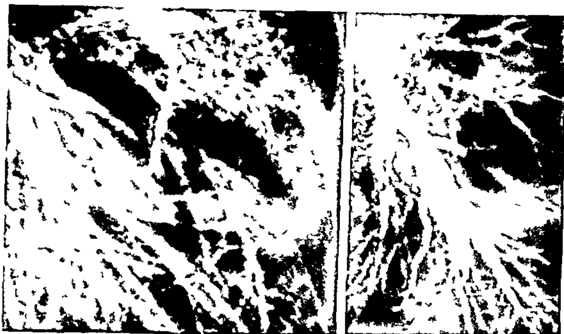


Fig 3 Bronchography in June 1966 p a and lateral projections Slight displacement of bronchi around the infiltrate small irregularities in the bronchial lumen but no occlusion no contrast filling of the cavities

As the possibility of malignancy could not be excluded the lobe containing the infiltrate was removed

Pathologic features The re ected lobe was normal in size and a mass fairly well demar cated from the lung parenchyma lay centrally in the lobe (Fig 4) The cut surface was moderately firm and greyish white in colour with cystic spaces measuring up to 2 cm in diameter these were in direct communication with the bronchi The re t of the lung parenchyma had a normal structure

Microscopy revealed that the infiltrate was composed largely of lymphoid tissue The cells were small round and lymphocyte like with a slight degree of polymorphism (Fig 5) There was no noticeable stroma but in some places rests of alveolar wall structure were observed No sharp line of demarcation between normal lung tissue and the tissues of the lesions could be seen (Fig 6) and no true germinal centers were present The cells of the lesions surrounded the arteries veins and bronchi and some lay in direct contact with the epithelial cells The bronchi and cyst like spaces in the tumor were lined by partly ciliated epithelium (Fig 7) Sections from small peribronchial lymph nodes revealed no changes The peripheral lung parenchyma was normal in appearance The lesion appeared to be a relatively mature lymphocytic lymphoma of the lung

Discussion

Primary pulmonary lymphomas are rare and are therefore not often considered by the clinician in the differential diagnosis of lung tumors Since the lesion may



Fig 4 Large section of the lower lobe of the left lung The cystic tumor (*shaded area in the schematic drawing*) was situated in the hilar region

produce no symptoms in the early stages it is usually detected by routine chest examination The roentgenographic appearances are not typical but a solitary homogenous rounded infiltration is usually present (STERNBERG et coll 1959) The margins are somewhat unsharp and irregular so that there may be some resemblance with metastatic lymphomas and primary bronchogenic carcinomas Primary pulmonary lymphomas differ from benign and metastatic tumors in that the latter have sharply defined edges

The most striking feature that differentiates lymphocytic lymphomas from other malignant neoplasms is their extremely slow rate of growth SALTZSTEIN (1963) thought that some of the highly differentiated lymphocytic tumors represented benign lesions of inflammatory type and referred to them as pseudo-lymphomas Another highly characteristic aspect is that even if the mass is very large *its mainly extrabronchial growth precludes atelectasis This feature is il*lustrated by the case reported in the present paper

Open bronchi may sometimes be observed passing through the lesion in ordinary chest films or bronchograms (STERNBERG et coll 1959) There may be slightly generalized narrowing of the lumen corresponding to the infiltration as illustrated in Fig 3 A bronchogenic carcinoma of the same size would almost invariably produce total occlusion of the bronchi with atelectasis

In the present case marked cavitation occurred in the interval between the two series of examinations and multiple rounded cyst like formations with thin walls developed This appears to be an uncommon finding in primary pulmonary lymphoma (COOLEY et coll 1956 ROBBINS 1953 and STERNBERG et coll 1959) Tuberculosis must be considered in the differential diagnosis and in our case repeated examinations of the sputum and gastric washings failed to reveal tubercle bacilli a guinea pig test was negative A bronchogenic cyst is always possible



Fig 3 Bronchography in June 1966 p a and lateral projections Slight displacement of bronchi around the infiltrate small irregularities in the bronchial lumen but no occlusion no contrast filling of the cavities

As the possibility of malignancy could not be excluded the lobe containing the infiltrate was removed

Pathologic features The resected lobe was normal in size and a mass fairly well demarcated from the lung parenchyma lay centrally in the lobe (Fig 4) The cut surface was moderately firm and greyish white in colour with cystic spaces measuring up to 2 cm in diameter these were in direct communication with the bronchi The rest of the lung parenchyma had a normal structure

Microscopy revealed that the infiltrate was composed largely of lymphoid tissue The cells were small round and lymphocyte like with a slight degree of polymorphism (Fig 5) There was no noticeable stroma but in some places rests of alveolar wall structure were observed No sharp line of demarcation between normal lung tissue and the tissues of the lesions could be seen (Fig 6) and no true germinal centers were present The cells of the lesions surrounded the arteries veins and bronchi and some lay in direct contact with the epithelial cells The bronchi and cyst like spaces in the tumor were lined by partly ciliated epithelium (Fig 7) Sections from small peribronchial lymph nodes revealed no changes The peripheral lung parenchyma was normal in appearance The lesion appeared to be a relatively mature lymphocytic lymphoma of the lung

Discussion

Primary pulmonary lymphomas are rare and are therefore not often considered by the clinician in the differential diagnosis of lung tumors Since the lesion may



Fig. 7. Cyst lined by somewhat irregular ciliary epithelium. H. & E. Approx. × 200.

on cytologic examination of the sputum or bronchoscopic biopsy. As the growths usually fail to invade or destroy the bronchial epithelium, diagnostic methods based on the examination of intrabronchial cell material or superficial bronchial biopsies are seldom diagnostic. Needle biopsy performed under fluoroscopy (DAHLGREN & NORDENSTROM 1966) would probably be of value in such cases. Most of the pulmonary lymphomas hitherto reported have, however, been diagnosed by histologic examination of tissue obtained at operation. It should however be stressed that it is not possible from microscopy alone to differentiate *between primary pulmonary lymphoma and disseminated lymphoma spreading* to the lung. The literature indicates that the prognosis is quite different in these two types of lymphomas (STERNBERG et coll. 1959, AHREN & ZETTERGREN 1963).

The lymphoma had in the present case grown slowly without causing symptoms for about eleven years, during which period no treatment had been given. This characteristically long survival without distant spread is similar to what is typical in primary lymphomas of the stomach and intestine (MCSWAIN & BEAL 1944, THORBJARNARSON et coll. 1956). In spite of the fact that the prognosis without therapy seems to be fairly good, excision of the involved portion of lung and the mediastinal lymph nodes is usually indicated. The difference in the recurrence rate between lobectomy and pneumonectomy seems to be insignificant. According to COOLEY et coll. (1956) postoperative radiation therapy is always indicated.

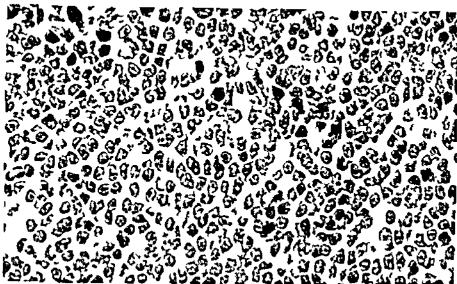


Fig 5 Relatively mature lymphocytic lymphoma without germinal centers in central part of tumor H & E Approx × 550



Fig 6 Infiltration of tumor cells in the alveolar septa in peripheral part of the tumor H & E Approx × 200

in cases of multilocular cyst formation but films from the earlier examination precluded this conclusion in our case

Only a few of the cases of pulmonary lymphoma described have been correctly diagnosed before operation (Rose 1957) The diagnosis in these cases was based



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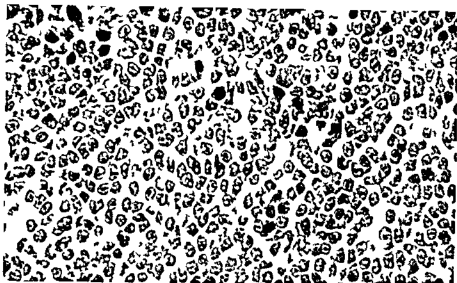


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SUMMARY

A case of primary lymphocytic cell lymphoma of the lung is described The growth increased only slightly over ten years and no evidence of distant spread could be detected The diagnostic problems, the prognosis and the treatment of these rare tumors are discussed

ZUSAMMENFASSUNG

Ein Fall mit primärem Lymphocytentumor in der Lunge wird beschrieben Die Geschwulst wurde während zehn Jahren nicht viel grösser und keine Zeichen auf distale lymphogene Aussaat konnten entdeckt werden Die diagnostischen Probleme die Prognose und die Behandlung dieser seltenen Tumoren werden erörtert

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Description d'un cas de lymphome primitif du poumon à cellules lymphocytiques Cette tumeur n'a que peu augmenté de volume pendant dix ans et on n'a trouvé aucun signe de dissémination à distance Les auteurs examinent les problèmes diagnostiques le pronostic et le traitement de ces tumeurs rares

REFERENCES

AHREN Ch och ZETTERGREN L Primart lymfosarkom i lungorna (In Swedish) Opusc med *8* (1963) 255

BECK W C and REGANIS J C Primary lymphoma of lung review of literature report of 1 case and addition of 3 other cases J thorac Surg *22* (1951) 323

COOLEY J C McDONALD J R and CLAGETT O T Primary lymphoma of lung Ann Surg 143 (1956) 18

DAHLGREN S and NORDENSTROM B Transthoracic needle biopsy Almqvist & Wiksell/Gebers Forlag Stockholm 1966 Also distributed by Year Book Medical Publishers Chicago 1966

McSWAIN B and BEAL J M Lymphosarcoma of gastro intestinal tract report of 20 cases Ann Surg 119 (1944) 108

ROBBINS L L Roentgenological appearance of parenchymal involvement of lung by malignant lymphoma Cancer 6 (1953) 80

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ANATOMIC AND PHYSIOLOGIC ASPECTS OF RESPIRATORY KYMOGRAPHY

by

SAM SCHMIDT

The results of respiratory kymographic examinations in various acute abdominal nd pulmonary conditions have been reported in earlier papers (SCHMIDT 1960 963 1966) and the value of the method in diagnosis has been discussed

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The examinations have been carried out with the same technique as previously lescribed

1 Anatomic and physiologic considerations in respiratory kymography

The kymographic examinations refer to the lower half of the chest i e approximately from the 7th to the 10th ribs and the diaphragm these latter move in longitudinal transverse and sagittal directions during respiration

The main component of the diaphragmatic movements and the only one which has a respiratory effect is the craniocaudal or longitudinal movement

Submitted for publication 9 April 1968

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According to physiologists, the diaphragm is the chief muscle involved in breathing. WADE (1954) calculated that 75 % of the vital capacity is due to the downward movement of the diaphragm during inspiration.

I have experimented with slits placed at right angles to tangentials to the lateral parts of the diaphragmatic cupoles, i.e. at 30° angles to the longitudinal axis of the body. Compared with ordinary kymographies made with longitudinal slits there were no appreciable differences in amplitudes and waveforms but owing to the obliquity the tracings were somewhat deformed and thus less suitable for interpretation.

The fact that the most important component of the diaphragmatic movements is the longitudinal one thus applies to all parts of the diaphragm though the various parts have different amplitudes. Accordingly, the statement in my first paper (1960) about the movements of the lateral parts of the diaphragm as not being in the direction of the longitudinal slits of the kymograph was incorrect. Even there, the principal direction of the movements is longitudinal, i.e. parallel to the median plane of the body.

The respiratory rib movements are more complex and take place around the axis of the costal necks although the main direction is craniocaudal (WADE 1954), especially as far as the posterior or dorsal parts of the 7th to 10th pairs of ribs are concerned. The ribs rise during inspiration and thus increase both the dorsoventral and lateral diameters of the thoracic cage.

The differences in amplitude in different ribs and in different parts of the same rib are relatively great. The respiratory amplitudes of the 7th to 10th pairs of ribs increase from below upwards: the movements of the 10th pair of ribs are smaller than those of the 9th pair which in turn are less than those of the 8th pair. The amplitude of the posterolateral parts of the ribs is obviously greater than that of the medial parts close to the vertebral articulations. The tracing of rib movements is recorded simultaneously with the diaphragmatic movements and through the same slits of the kymograph.

As pointed out in a previous paper (SCHMIDT 1966) the kymographic tracing is produced by the movements of the diaphragm and ribs at the point of intersection with the immobile slits of the kymograph while the film is moving. The position of this point on the surface of the diaphragm or ribs obviously varies continuously during respiration (cf. Fig. 2).

2. The normal respiratory kymogram and its variations in males and females and in dextrocardia

The material consists of 55 healthy individuals who underwent routine examination for employment, 27 were males aged from 22 to 51 years and 28

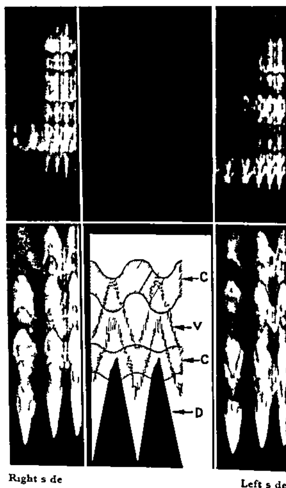


Fig 1 Normal kymographic tracings in ordinary respira t on (upper) and deep respiration (lower) The dia phragmatic ampl tude is smaller on the left s de because of the heart C — co tal movement wave D — dia phragmatic movement wave V — mo ement wave of a pulmonary vessel

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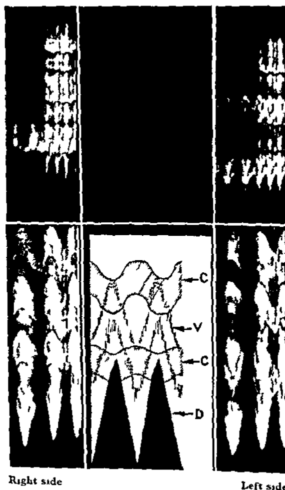


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groups or eliminated alternatively the results are R > L in 37 5/55 cases and R > I in 29/38 cases The results by binomial distribution would thus indicate a significant predominance of greater amplitudes of the right as compared with the left hemidiaphragm This contradicts the established opinion that because of the liver the excursion of the right hemidiaphragm is less than that of the left one

Costal respiratory movements (Fig 1)

Waveform The tracing of a costal respiratory cycle was a relatively flat slightly asymmetric undulating wave whose direction was opposed to that of the diaphragmatic wave The transition between inspiration and expiration and vice versa was smooth and rounded As in the diaphragmatic tracing there was no appreciable difference in waveform between males and females

Amplitude The movements of the posterolateral parts of the 7th to 10th ribs are usually recorded The costal amplitude in ordinary breathing was usually small and often unappreciable Consequently only amplitudes in deep breathing were considered in this study

The mean amplitudes with standard deviations on the right and left sides in males and females are presented in the Table There was no statistically significant difference between the two sides nor between males and females

A respiratory index has been created to indicate the relationship between costal and diaphragmatic respiratory amplitudes in males and females This index was obtained by dividing in each case the costal amplitude (in millimeters) by the diaphragmatic amplitude (in centimeters) during deep breathing

$$\frac{\text{C ampl}}{\text{D ampl}} = \text{respiratory index (R I)}$$

The results were in males R I = 1 12 ± 0 88 and in females R I = 1 52 ± 0 91 There was no statistically significant difference at a 5 % level between males and females (see Table)

It has been found that the respiratory index may provide valuable information in kymographic examinations in cases of emphysema and other respiratory disturbances This will however not be dealt with in this connection

Dextrocardia

As mentioned earlier twelve cases of dextrocardia were examined so as to control the diaphragmatic amplitude results (Fig 3) These consisted of 5 males

Table

Normal diaphragmatic and costal amplitudes and respiratory index with standard deviations in males and females

		Males		Females		Statistical significance of differences between males and females (T test) P=5%
		Right side	Left side	Right side	Left side	
Normal respiration	Diaphragmatic amplitude	2 3±0 9 cm	2 1±0 7 cm	2 1±0 6 cm	2 0±0 6 cm	—
Deep respiration	Diaphragmatic amplitude	6 1±1 8 cm	5 7±1 8 cm	4 9±1 8 cm	4 6±1 7 cm	+
	Costal amplitude	5 8±4 2 mm	5 8±4 2 mm	6 3±2 9 mm	7 7±3 9 mm	—
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Waveform The kymographic tracing of a normal diaphragmatic movement was of a regular, slightly asymmetric, steep wave The ascending expiratory arm was straight except in its upper part where it was slightly levelled off indicating some slowing down towards the end of expiration The descending or inspiratory arm consisted of a straight line with the apex of the wave representing transition from expiration to inspiration usually forming an acute angle The concavity of the wave indicating transition from inspiration to expiration was most often pointed although sometimes rounded There was no appreciable difference in waveform between males and females

Amplitude The method allows for an accuracy of 0 5 cm in the diaphragmatic amplitude and 1 mm in the costal movements, as measured on the films The mean diaphragmatic and costal amplitudes with standard deviations on the right and left sides in males and females are given in the Table

The diaphragmatic amplitude in deep respiration was on a 5 % level significantly greater in males than in females

The diaphragmatic amplitudes in males and females together produced the following figures greater on right than on left side in 29 cases equal on right and left sides in 17 cases and smaller on right than on left side in 9 cases

If the number of cases with R = L is divided equally between the other two

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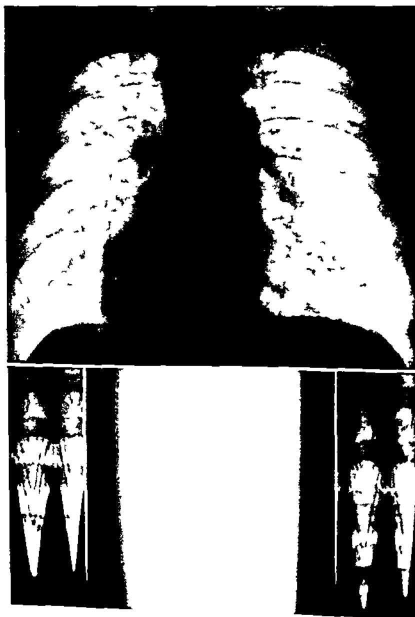


Fig 3 Situs inversus. Kymography in deep respiration of normal appearance (lower image) The diaphragmatic amplitude is smaller on the right side because of the heart

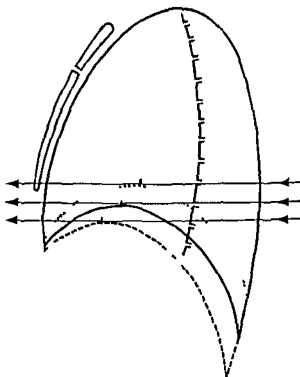


Fig 2 Schematic tracing showing the points of intersection of the roentgen beam passing through the slits of the kymograph with the highest point of the diaphragmatic surface during respiration diaphragm in expiration ( ) diaphragm in ordinary inspiration (———) and diaphragm at the end of deep inspiration ( )

and 7 females aged from 18 to 69 years All except two were healthy, with normal roentgenologic heart and lung findings One of them, a man aged 69, had a slightly enlarged heart and a minor left lateral pleural adhesion Another male, aged 48, had some minor fibrotic changes at the right apex Eight of the subjects had situs inversus both of thoracic and abdominal organs Four had a rotation anomaly with dextrocardia but with normally situated aorta and liver

Diaphragmatic respiratory movements in dextrocardia (Fig 3) The *waveform* was bilaterally normal in ten cases and stepformed in one In another case it was stepformed on the right and normal on the left side

The *amplitudes* were within normal limits in all the subjects The amplitudes of the right and left hemidiaphragm considered separately were as follows on right side smaller than on left in 7 cases, equal on right and left sides in 4 cases, and greater on right side in one case These results indicate a clear tendency to a smaller diaphragmatic amplitude on the right side

Costal respiratory movements in dextrocardia (Fig 3) These were normal both in *waveform* and *amplitude*

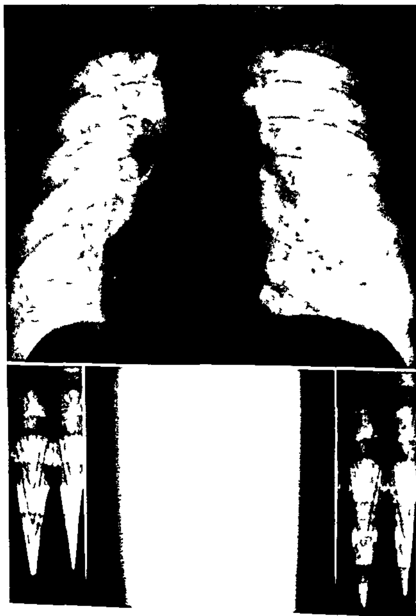


Fig 3 Situs inversus. Kymography in deep respiration of normal appearance (lower image) The diaphragmatic amplitude is smaller on the right side because of the heart

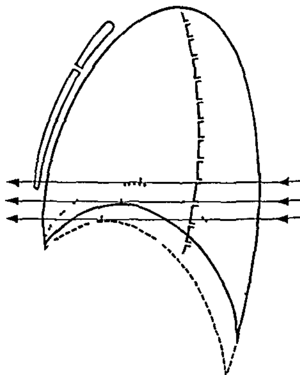


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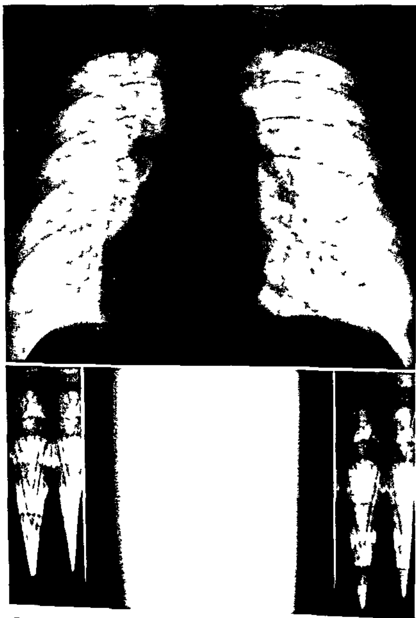


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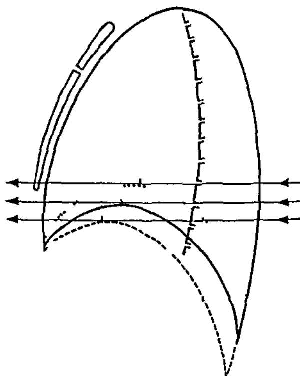


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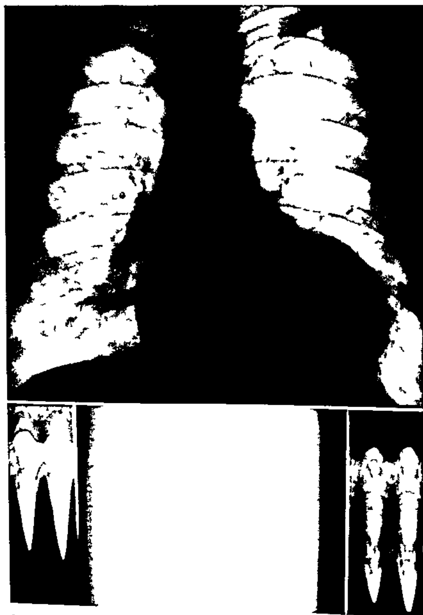


Fig 4 Co s derab ly enlarged heart (aortic stenosis) Kymography in deep resp a tion (lower image) The d aphragmatic amplitude is reduced on the left side be cau e of the heart otherwise no mal appearances

The results are in accord with the findings in the fifty five normal cases in which a *significantly greater diaphragmatic amplitude* was present on the right as compared with the left side. The results also agree with the observations made by CARLSON, KINCAID & ONGLEY (1962) who wrote "the relative position of the two hemidiaphragms is not primarily dependent on the position of the liver as is widely believed but predominantly on the position of the heart, the mass and activity of which depress the underlying hemidiaphragm".

3. Respiratory kymography in cases with enlarged hearts

The material consists of 12 cases, 8 men and 4 women, aged between 50 and 86 years. The diagnoses were myocardial sclerosis in 7 cases, aortic valve stenosis in 3 cases, mitral valve disease in one case and acute incompensation in one case.

The heart volume in the male patients varied from 1 280 ml to 1 740 ml, the average being 1 558 ml, i.e. about 85 % enlargement compared with the normal average. In female patients the heart volume varied from 920 ml to 1 960 ml, the average being 1 302 ml, i.e. approximately 100 % above the normal.

Slight to moderate stasis in the lungs was present in six cases. The remaining six cases had no stasis. *There was no appreciable difference in the kymographic* appearances between these two groups.

Diaphragmatic respiratory movements (Fig. 4)

Waveform. This was bilaterally normal in eleven cases and stepformed in one case. The latter presented no pulmonary changes at the time of kymography but bilateral pleural effusions had been present a fortnight earlier.

Amplitude. This was bilaterally average in one case and moderately reduced in one case. In a further four cases, the amplitude was within normal limits but the movements were less on the left side, with differences of up to 2 cm compared with the right side. In five cases the amplitude was moderately reduced on the left side and average on the right side. Finally, in one case with a considerably enlarged heart the amplitude was moderately reduced on the right side. The left diaphragmatic tracing could not be recorded because of the very large heart, the total volume of which was 1 960 ml. Thus, in nine cases out of the eleven the diaphragmatic amplitude was smaller on the left than on the right side.

Costal respiratory movements (Fig. 4)

Waveform. This was bilaterally normal in all the cases.

Amplitude. This was bilaterally average in six cases and moderately reduced

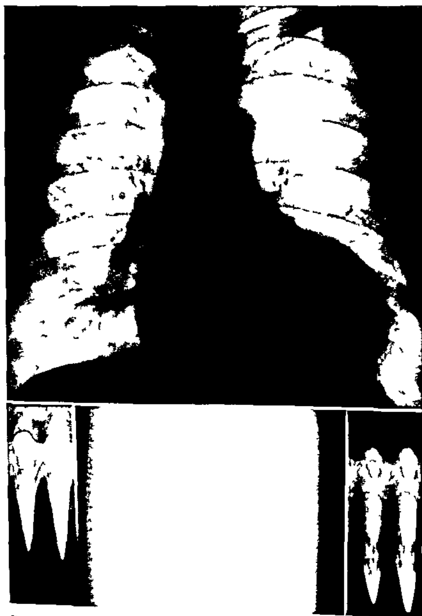


Fig 4 Con iderably enlarged heart (aortic stenos s) Kymog aphy n deep resp a tion (lower im ge) The diaphragmatic amplitude is reduced on the left side be ause of the he rt otherwise normal appearances

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Slight to moderate stasis in the lungs was present in six cases The remaining six cases had no stasis There was no appreciable difference in the kymographic appearances between these two groups

Diaphragmatic respiratory movements (Fig 4)

Waveform This was bilaterally normal in eleven cases and stepformed in one case The latter presented no pulmonary changes at the time of kymography but bilateral pleural effusions had been present a fortnight earlier

Amplitude This was bilaterally average in one case and moderately reduced in one case In a further four cases, the amplitude was within normal limits but the movements were less on the left side, with differences of up to 2 cm compared with the right side In five cases the amplitude was moderately reduced on the left side and average on the right side Finally, in one case with a considerably enlarged heart the amplitude was moderately reduced on the right side The left diaphragmatic tracing could not be recorded because of the very large heart, the total volume of which was 1 960 ml Thus, in nine cases out of the eleven the diaphragmatic amplitude was smaller on the left than on the right side

Costal respiratory movements (Fig 4)

Waveform This was bilaterally normal in all the cases

Amplitude This was bilaterally average in six cases and moderately reduced



Fig 5 Acute left side pyelonephritis with calculus in left ureter no pulmonary changes Kymography in deep respiration Reduced costal amplitude on the left side (arrows) Bilaterally normal diaphragmatic amplitude and waveform

on the left side this was one of nephritis with a left pleural effusion of moderate size

Of the six cases with unilateral lesions five had average and equal amplitudes on both sides and one had a moderately reduced amplitude bilaterally

Costal respiratory movements (Fig 5)

Waveform This was bilaterally normal in ten cases and stepformed in one case which also had stepformed diaphragmatic waves The movements were paradoxical during deep respiration in one case These last two cases of acute nephritis exhibited no pulmonary changes

Amplitude This was bilaterally average in three cases and slightly or moderately reduced in two cases The movements were paradoxical in one case (as stated above) These were the six cases with bilateral lesions five cases of glomerulonephritis and one of pyelonephritis In the six cases with unilateral lesions the costal amplitude on the affected side was markedly reduced On the contralateral side the amplitude was an average or increased

in three cases In two cases, the amplitude was average on the right and increased on the left side In one case, finally, the costal amplitude was normal on the right and moderately reduced on the left side and there was a small pleural effusion on the left side

Cases with enlarged livers

Eight of the cardiac cases had enlarged livers, palpable at 2 to 4 finger breadths below the costal margin Six of these had an average diaphragmatic amplitude on the right side although greater than the one on the left side One case had an average amplitude on both sides, and in one case the amplitude on the left side could not be recorded

The costal amplitude was average on the right side in six cases and moderately reduced in two cases On the left side the amplitude was average in three cases, reduced in three and increased in two cases

4 Respiratory kymography in acute renal processes

The material consists of 12 cases, 8 males and 4 females, aged between 13 and 66 years The diagnoses were acute or subacute glomerulonephritis in 5 cases, acute pyelonephritis in 3 cases, acute perinephritis in 3 cases and perinephric haemorrhage in one case

In six of these cases the process was unilateral three cases of acute peri nephritis, two cases of unilateral acute pyelonephritis and one case of perinephric haemorrhage Eight of the cases had normal lungs on roentgen examination One case with right-side acute perinephritis had a minor infiltration at the right base with a small pleural effusion Another case of right side perinephric haemorrhage had a small pleural adhesion at the left base A small pleural effusion on the left side was present in a case of subacute nephritis The lungs were not examined in one case of subacute nephritis

Diaphragmatic respiratory movements (Fig 5)

Waveform This was bilaterally normal in ten cases and stepformed in two cases, the latter had no lung changes but one of them was undergoing peritoneal dialysis

Amplitude This was bilaterally average in eight cases, slightly reduced in two and markedly reduced in one case This last case, which also had bilateral step-formed diaphragmatic movement waves, was treated with peritoneal dialysis One case had an average amplitude on the right and a slightly reduced amplitude

No plateau shaped waves were observed in the present series.

It may be mentioned with reference to the case of nephritis with left basal broncho-pneumonia reported in an earlier paper (SCHMIDT 1962) that the diaphragmatic waveform was plateau shaped bilaterally only in the deep-breathing kymogram and the amplitude was only slightly reduced — In severe abdominal conditions with peritonitis the diaphragmatic amplitude is generally considerably reduced — The plateau shaped waveform in the case mentioned was probably a result of slow respiration and a short cessation of breathing after each expiration

Conclusion

The results in normal cases indicate a statistically significant predominance of smaller amplitudes of the left cupole of the diaphragm as compared with the right cupole they have been confirmed by the findings in twelve cases of dextrocardia in the majority of which the amplitude of the right diaphragmatic cupole was smaller than on the left side Similar results were obtained in the majority of the twelve cases of cardiac enlargement including the eight cases with enlarged liver in which the amplitude of the left side of the diaphragm was reduced

These results are against the common belief and indicate that it is the heart and not the liver that exercises a braking influence on the diaphragm

Twelve cases of acute renal and perirenal processes were examined In nine of these the costal respiratory amplitude was reduced the reduction being most marked on the affected side in unilateral processes The diaphragmatic waveform and amplitude as well as the costal waveform were generally normal

These results are in disagreement with the general opinion that a perinephric process causes movement restriction or paralysis of the diaphragm on the affected side

A close relationship between the innervation of the kidneys and rib muscles may explain the kymographic appearances

Acknowledgement

The author wishes to express his gratitude to the Memorial Foundation Claes Groschinsky for financial support of the investigation

SUMMARY

The kymographic appearances produced by the movements of the diaphragm and rib during respiration were investigated in fifty five normal cases with twelve cases of dextrocardia as controls Twelve cases of cardiac enlargement including eight cases of hepatic enlargement and twelve cases of acute renal processes were similarly examined The effect

Discussion

Normal cases and cases with enlarged heart Restriction of the diaphragmatic movements on the left side appears to be a constant finding in cardiac enlargement Waveforms, diaphragmatic and costal, and amplitudes of rib movements, are generally not affected These observations are in agreement with the findings in the fifty five normal control cases in which a statistically significant predominance of smaller amplitude of the left hemidiaphragm was noted They also agree with the findings in the majority of the twelve cases of dextrocardia, as previously described

Reduction of the diaphragmatic amplitude on the left side can be explained by the mass and activity of the overlying heart The heart is in fact a relatively heavy and relatively incompressible organ firmly anchored by the aorta and other large vessels as well as by the pericardial ligaments In cardiac enlargement a still greater part of the left diaphragmatic cupole comes in contact with the heart which acts as a brake upon its movements during its ascent

No direct correlation could be found between the cardiac volume and the degree of amplitude reduction on the left side of the diaphragm

Enlargement of the liver does not appear to affect the diaphragmatic or the costal respiratory movements This is against the common belief that the liver exerts a braking influence on the overlying hemidiaphragm

Acute renal processes Acute renal disease does not generally affect the form of the diaphragmatic or costal respiratory movements Stepformed diaphragmatic movements in two cases can possibly be explained by a reaction to slightly painful respiration The diaphragmatic amplitude does not appear to be affected in renal infection, even in cases of acute perinephritis The costal amplitude appears on the contrary to be involved generally, reduction in the costal amplitude occurs and in unilateral processes is more marked on the affected side

The kidney is not held in place by any special folds of peritoneum or ligaments and is not attached to neighbouring organs The afferent nerve fibres that supply the kidney are connected with the 10th, 11th and 12th thoracic nerves The anterior primary rami of the thoracic nerves are the intercostal nerves which are the motor nerves of rib muscles This could explain the intimate relations between the kidney and the rib movements

Paradoxical rib movements in deep breathing are probably not pathologic Indeed, the author has observed such movements in healthy individuals HOLZKNECHT (cited in Rontgenkymographische Bewegungslehre 1934) has also reported the same phenomenon in normal subjects A plausible explanation is that the lower ribs passively follow large diaphragmatic excursions

FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR U RUDHE) THE PAEDIATRIC CLINIC, KAROLINSKA SJUKHUSET, STOCKHOLM SWEDEN

PULMONARY VASCULAR DISPARITY IN FALLOT's ANOMALY AND IN SIMPLE PULMONARY VALVE STENOSIS

by

CARLOS QUIROGA and ULF RUDHE

Unequal vascularity of the two lungs in congenital heart disease with a left-to-right shunt has been reported by FLEMING 1959, GARFUNKEL & KIRKPATRICK 1961 1963 DOLLERY et coll 1961 WHITLEY RUDHE & HERZENBERG 1963 and SCHISMANOV 1968 Studies of the discrepancy in the vascularity of the lungs in Fallot s anomaly with agenesis of the left pulmonary artery (NADAS et coll 1953 KJELLBERG et coll 1959 EMANUEL & PATTINSON 1956 *among others*) and extrinsic compression of the right pulmonary artery (PORSTMAN EL SALLAB & DAVID 1967) have been made although other reports are sparse WILSON & AMPLATZ in 1967 *recorded a disparity* in the vascularization of the right and left upper lobes in 20 of a series of 100 cases of Fallot s tetrad

The present study was undertaken to test the hypothesis of the direction of the outflow tract of the right ventricle and the main pulmonary artery being of significance by indicating discrepancies in the vasculature of the two lungs in Fallot s anomaly It was also hoped to determine whether the appearances of the systolic

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of the heart, renal processes and other factors upon the diaphragmatic and the costal movements are discussed in detail

ZUSAMMENFASSUNG

Die von den Atmungsbewegungen des Zwerchfells und der Rippen verursachten kymographischen Erscheinungen wurden studiert Das Material besteht aus funfundfunfzig Normalfallen und zwolf Vergleichsfallen von Dextrokardie Ferner wurden zwolf Falle mit Herzvergrosserung, einschliesslich acht Falle mit Leververgrosserung und zwolf Falle mit akuten Nierenprozessen untersucht Der Einfluss des Herzens renaler Prozessen und anderer Faktoren auf dem Bewegungsverlauf des Zwerchfells und der Rippen wird detailliert besprochen

RÉSUMÉ

L auteur a étudié les images kymographiques des mouvements du diaphragme et des cotes pendant la respiration chez cinquante cinq sujets normaux et dans douze cas de dextrocardie Il a examine par la meme methode douze cas de cardiomegalie comprenant huit cas d hepatomégalie et douze cas d affection rénale aigue Il examine en detail l influence du cœur des affections renales et d autres facteurs sur les mouvements respiratoires diaphragmatiques et costaux

REFERENCES

ARNER O ERIKSSON F and SUNDBLAD R Epigastric incisional hernia Acta Chir Scand Suppl (1963) No 320

CARLSON H C, KINCAID O W and ONGLEY P A Some observations on the relative influence of the heart and liver on the position of the diaphragm Proc Mayo Clin 37 (1962) 25

DAHM M Rippen und Zwerchfellbewegung im Rontgenbild Fortschr Rontgenstr 47 (1933) 276

EPSTEIN B S Roentgen kymography of the diaphragm Amer J Roentgenol 74 (1955) 70

RICHARDS JR D W External respiration *In* Medical physics Volume II p 836 Edited by Otto Glasser Year Book Publishers Chicago 1950

SCHMIDT S Respiratory kymography in acute abdominal conditions Acta radiol 54 (1960) 49

— (a) Respiratory kymograpy in acute pulmonary disease Acta radiol Diagnosis 1 (1963) 1032

— (b) Respiratory kymography in postoperative pulmonary complications Acta radiol Diagnosis 1 (1963) 1091

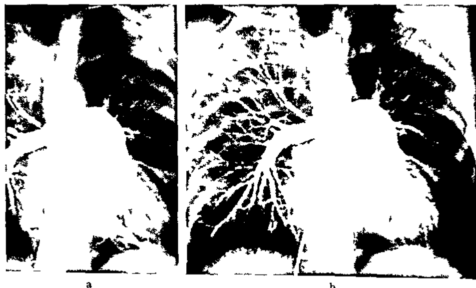
— Further studie on respiratory kymography in acute abdominal conditions Radiology 86 (1966) 15

— Respiratory kymography in differential diagnosis between acute abdominal and acute pulmonary conditions Acta chir scand 132 (1966) 143

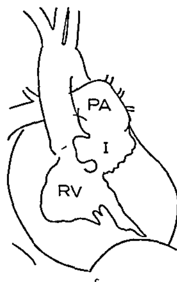
STUMPF P WEBER H H und WELTZ G A Rontgenkymographische Bewegungslehre innerer Organe George Thieme Leipzig 1936

WADE O L Movements of the thoracic cage and diaphragm in respiration J Physiol 124 (1954) 193

— and GILSON J C The effect on posture of diaphragmatic movements and vital capacity in normal subjects with a note on spirometry as an aid in determining radiological chest volumes Thorax 6 (1951) 103



a b



c

Fig Fallot s nomaly with infundibular and valvular pulmonary stenos s Prev ous attempts at blind infun dibulectomy failed to relieve obstruction a) Outflow tract and pulmonary trunk run a ertical course b) The arteries of the ent e left lung and especially of the upper lobe are markedly narrower than on the right s de the right pulmonary artery is 4 mm wider than the left c) Schematic drawing of (a)

cross-sectional area of the arteries was not determined (CASTELLANOS & HERNANDEZ 1967)

Appreciation of the degree of vascularity of the lungs was based on a comparison of the relative widths of the vessels of the two lungs so that their caliber



Fig 1 Fallot s anomaly with infundibular and valvular pulmonary stenosis Right ventricular outflow tract and pulmonary trunk inclined towards the right right and left pulmonary arteries both emerge without angulation from the pulmonary trunk with the typical configuration present in Fallot s anomaly a blind ductus projects from the trunk Equal vascularity of the lungs

jet in the pulmonary artery were of equal significance in pulmonary valve stenosis with an intact ventricular septum

Material and Methods Angiocardiograms of a consecutive series of 119 cases with Fallot s anomaly and 81 cases with pulmonary valve stenosis with intact ventricular septum were reviewed Cases with agenesis of the left main branch of the pulmonary artery, peripheral pulmonary stenosis and those treated with a Blalock Taussig anastomosis were excluded Angiocardiographic studies had been performed in simultaneous frontal and lateral views with the Elema roll film changer (Gidlund system) and injection of the contrast medium into the right ventricle With few exceptions, the exposure time did not exceed 0 016 seconds Six pairs of films per second were exposed Cine angiocardiography was not performed Pertinent clinical and haemodynamic data were available in all cases

The internal diameter of the right and left pulmonary arteries was measured in the angiocardiograms at a point approximately 1 5 cm from their origin at the trunk, both in frontal and lateral views whenever possible films exposed in ventricular systole were used When the right pulmonary artery displayed a variable caliber the mean value between that measured at the narrowest and widest points was determined As only the relative sizes of the arteries were of interest, no attempt was made to correct for enlargement caused by the diverging rays The



Fig 3 Fallot s anomaly with valvular and infundibular stenosis a) Outflow tract and pulmonary trunk directed towards the right a blind ductus is outlined b) The vessels in the left lung especially those in the upper lobe are wider than the vessels in the right lung right aortic arch

the difference in width ranging from 3 to 7 mm In the remaining case both main pulmonary arteries were markedly hypoplastic and collaterals contributed substantially to the relatively richer vascularity of the left lung The outflow tract deviated towards the right in six cases (Fig 3) and ran a vertical course in four All patients were cyanotic and presented evidence of combined valvar and infundibular stenosis A right aortic arch was present in five cases

The contrast filling and the caliber of the pulmonary veins when visible reflected the variations in the arterial vascularization in all the four groups The cours of the pulmonary artery trunk when assessed in the frontal film differed from that of the outflow tract of the right ventricle in less than a third of the hearts The most common disalignement was deviation of the pulmonary artery to the right while the infundibulum followed an almost vertical course Although most cases of asymmetric vascularity of the lungs occurred in this category the right lung being more vascularized than the left equal vascularization was more common In addition in several of the cases in this group the left artery was better aligned to the trunk than the right artery and was associated with either equal vascularity of the lungs or hypovascularity of the left lung Relative hypervascularity of the left lung or upper lobe was seen in four cases with the pulmonary artery trunk projecting towards the right (Fig 3) and in three cases with this vessel in the midline

The systolic jet in the pulmonary trunk was outlined only rarely and did not

was not measured The same methods were applied to the study of the veins of the right and left lungs

The orientation of the outflow tract of the right ventricle and the main pulmonary artery was assessed from the frontal films correlated with the findings in the lateral views

Results

Fallot's anomaly

The cases may be grouped into four classes following analysis of the pulmonary vascularity and orientation of the right ventricular outflow tract

Group 1 (79 cases) These displayed equal vascularity of the lungs and no abnormal deviation of the outflow tract of the right ventricle or the main pulmonary artery The pulmonary arteries were also equal in caliber, the differencies in width never exceeding 2 mm All patients were cyanotic

Group 2 (18 cases) The vascularity of the lungs was equal but a deviation of the outflow tract from a straight course was observed The main right and left pulmonary arteries were equal in width in all the eighteen cases The outflow tract of the right ventricle ran in oblique course, towards the right in thirteen cases (Fig 1) and towards the left in four cases, and pursued a tortuous course towards the right in the remaining case Combined valvar and infundibular stenosis was present in twelve cases and only infundibular stenosis in the remaining six cases A right aortic arch was recorded in six cases Fourteen patients were cyanotic and four were acyanotic

Group 3 (12 cases) Relative hypovascularity of the entire left lung was present in eleven cases and was limited essentially to the left upper lobe in an additional case In all the twelve cases the right pulmonary artery was wider than the left the difference ranging from 2 to 18 mm A slight local constriction was present in the left pulmonary artery in one instance The outflow tract of the right ventricle pursued an oblique course towards the right in nine cases and was parallel to the spine in two cases (Fig 2) In the remaining case the outflow tract was greatly distorted and projected dorsad Combined valvar and infundibular stenosis was noted in one case A right aortic arch was observed in six cases All patients but one were cyanotic

Group 4 (10 cases) Five of these cases had richer vascularity in the whole of the left lung than in the right lung, and five had hypervascularity limited to the left upper lobe In nine cases, the left pulmonary artery was wider than the right,

Discussion

The works of GARFUNKEL & KIRKPATRICK and WHITLEY, RUDHE & HERZENBERG describing the discrepancy in vascularization of the right and left lungs in congenital heart disease with left to right shunt did not clarify the underlying mechanism. WILSON & AMPLATZ considered the direction of the pulmonary artery jet to be the determining factor in Fallot's anomaly with inequality of the vascularity of the lungs. The jet was observed to propagate into the right or left pulmonary arteries or to be limited to the main artery. Depending on the direction of the outflow tract of the right ventricle, the left upper lobe was hypovascularized when the jet was directed into the right pulmonary artery, and vice versa. Such inequality of the vasculature was recorded in 20 per cent of their cases when assessed by inspection of conventional films of the chest. This abnormality, whether due to relative hypo- or hypervascularity, was noted in twenty-two of 119 cases of the present series studied angiocardiographically. Inequality of vascularity was invariably associated with a change in the dimensions of the main arteries and veins.

While a pulmonary artery jet was seen only rarely in the present series of Fallot's anomaly, the orientation of the outflow tract of the right ventricle and the pulmonary artery could be analyzed in detail. It did not correlate well with the radiologic impression of the degree of vascularization. It is true that relative hypovascularity of the left lung or left upper lobe was usually associated with deviation of the infundibulum to the right but the same course was noted in several cases with relative hypervascularity of the left lung and in twelve out of eighteen cases with equally vascularized lungs or upper lobes. It should be emphasized that due consideration was taken of the fact that in Fallot's anomaly the main pulmonary artery and its two branches may be well aligned despite a marked inclination of the former towards the right (cf. Fig. 1). The left pulmonary artery then arises from the right upper aspect and pursues a course upwards to the left. Both hypovascularity and hypervascularity of the left lung were present with this characteristic anatomy of the arteries.

The findings in pulmonary valve stenosis with intact ventricular septum, in which the systolic jet in the pulmonary artery may be powerful, did not support the hypothesis that the jet is of prime significance for the appearances of the pulmonary vascular tree. The direction and extent of the systolic jet in the eleven cases with relative hypervascularity of the left lung were no different from those present in 69 cases with equal vascularity of the lungs. Furthermore, it is more common for the right pulmonary artery to be wider than the left; this may well be so even if there be relative hypervascularity of the left lung (Fig. 4). These facts and the observation that in certain instances of heart lesions



Fig. 4. Pulmonary valve stenosis with intact ventricular septum, late systole. a) The right pulmonary artery is 3 mm wider than the left but the vascularity of the left lung is greater compared to the right lung; the systolic jet impinged on the anterosuperior wall of the pulmonary trunk (not shown). b) The left pulmonary veins are wider than the right.

propagate into the main branches of the pulmonary artery. There was no evidence of thrombosis of the pulmonary vessels.

Pulmonary valve stenosis

Unequivocal side to side disparity of arterial and venous vascularization of the lungs was demonstrated in twelve of 81 cases of pulmonary valve stenosis with intact ventricular septum, the left lung having wider vessels in eleven cases (Fig. 4), hypovascularity being present in only one case with a hypoplastic left artery. Contrary to the findings in Fallot's anomaly, the discrepancy of vasculature was not related to the relative calibers of the main branches. The left artery was either of the same width (4 cases), a few millimeters wider (3 cases) or narrower (4 cases), than the right artery, the case with a hypoplastic artery not being included. The systolic jet impinged on the superior wall of the main artery wall anterior to the area of the pericardial reflection and in none of the cases in the series propagated directly into the main branch of either side. Eddies were apparent in the left artery at its origin from the trunk in isolated cases but the left artery was no wider than the right artery. The right pulmonary artery as a rule was wider than the left artery in the large group with equal vascularity of the lungs. Consequently, no relation was established between either the direction of the pulmonary artery jet and its occasional propagation towards the left artery or the dimensions of the main branches and the vessels of the lungs.

Discussion

The works of GARFUNKEL & KIRKPATRICK and WHITLEY, RUDHE & HERZENBERG describing the discrepancy in vascularization of the right and left lungs in congenital heart disease with left to right shunt did not clarify the underlying mechanism. WILSON & AMPLATZ considered the direction of the pulmonary artery jet to be the determining factor in Fallot's anomaly with inequality of the vascularity of the lungs. The jet was observed to propagate into the right or left pulmonary arteries or to be limited to the main artery. Depending on the direction of the outflow tract of the right ventricle, the left upper lobe was hypovascularized when the jet was directed into the right pulmonary artery and vice versa. Such inequality of the vasculature was recorded in 20 per cent of their cases when assessed by inspection of conventional films of the chest. This abnormality, whether due to relative hypo- or hypervascularity, was noted in twenty two of 119 cases of the present series studied angiocardiographically. Inequality of vascularity was invariably associated with a change in the dimensions of the main arteries and veins.

While a pulmonary artery jet was seen only rarely in the present series of Fallot's anomaly, the orientation of the outflow tract of the right ventricle and the pulmonary artery could be analyzed in detail. It did not correlate well with the radiologic impression of the degree of vascularization. It is true that relative hypovascularity of the left lung or left upper lobe was usually associated with deviation of the infundibulum to the right but the same course was noted in several cases with relative hypervascularity of the left lung and in twelve out of eighteen cases with equally vascularized lungs or upper lobes. It should be emphasized that due consideration was taken of the fact that in Fallot's anomaly the main pulmonary artery and its two branches may be well aligned despite a marked inclination of the former towards the right (cf. Fig. 1). The left pulmonary artery then arises from the right upper aspect and pursues a course upwards to the left. Both hypovascularity and hypervascularity of the left lung were present with this characteristic anatomy of the arteries.

The findings in pulmonary valve stenosis with intact ventricular septum, in which the systolic jet in the pulmonary artery may be powerful, did not support the hypothesis that the jet is of prime significance for the appearances of the pulmonary vascular tree. The direction and extent of the systolic jet in the eleven cases with relative hypervascularity of the left lung were no different from those present in 69 cases with equal vascularity of the lungs. Furthermore, it is more common for the right pulmonary artery to be wider than the left; this may well be so even if there be relative hypervascularity of the left lung (Fig. 4). These facts and the observation that in certain instances of heart lesions



Fig 4 Pulmonary valve stenosis with intact ventricular septum late systole a) The right pulmonary artery is 5 mm wider than the left but the vascularity of the left lung is greater compared to the right lung the systolic jet impinged on the anterosuperior wall of the pulmonary trunk (not shown) b) The left pulmonary veins are wider than the right

propagate into the main branches of the pulmonary artery There was no evidence of thrombosis of the pulmonary vessels

Pulmonary valve stenosis

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pulmonary artery jet as well as by the orientation of the right ventricular outflow tract and the pulmo ary artery was not substantiated in the present investigation The findings present ed u gest that structural rather than haemodynamic factors may be of greater importance

ZUSAMMENFASSUNG

Die Hypothese dass die ungleiche Gefassversorgung der Lungen bei Fallotscher Tetrade und bei Pulmonalklappenstenose mit intaktem Ventrikularseptum von der Blutstromrich tung in der Pulmonalarterie und von der Orientierung des rechten Ausflusstraktes sowie der Pulmonalarterie abhangig sei konnte bei der gegenwartigen Untersuchung nicht best tigt werden Die Befunde deuten darauf hin dass die strukturalen Faktoren von grosserer Bedeu tung als die hamodynamischen sind

RESUME

L experimentation faite par les auteurs ne confirme pas l hypothese selon laquelle l inega lite de vascularisation des poumons dans l anomalie de Fallot et dans la stenose valvulaire pulmonaire avec septum ventriculaire intact peut etre due a la direction du jet de l artere pulmonaire et a l orientation de la chambre de chasse du ventricule droit et de l artere pul monaire Les resultats de cette experimentation font penser que les facteurs les plus impor tants sont structuraux plutot qu hemodynamiques

REFERENCES

CASTELLANOS A and HERNANDEZ F A The size of the right pulmonary artery in the normal subject and in congenital heart disease Radiology 100 (1967) 568

DOLLERY C T WEST J B WILCKEN G L and HUGH JONES P A comparison of the blood flow between left and right lungs in normal subjects and patients with congenital heart disease Circulation 24 (1961) 617

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with left-to-right shunt the vessels of the left upper lobe may be narrower than normal would indicate that structural rather than haemodynamic factors primarily determine the vascular inequality of the lungs demonstrated at angiography. However it should be stressed that the present investigation is essentially morphologic and does not allow detailed conclusions as to the magnitude or velocity of the pulmonary flow. These parameters should be determined with the aid of isotope examinations and other means.

The frequent occurrence of a right aortic arch in Fallot's anomaly associated with pulmonary artery malformations, particularly agenesis of the left pulmonary artery, has been emphasized by PATTINSON & EMANUEL 1957 and KIEFFER et coll. 1965 among others. Whether the high frequency of a right aortic arch associated with disparity of the vasculature of the two lungs in the present series of Fallot's anomaly (11/22 cases) is significant or occurs by coincidence is, however, not clear from this small series.

Conclusions

Unequal vascularity of the two lungs was encountered in 8 per cent of cases in Fallot's anomaly and in 15 per cent of cases of pulmonary valve stenosis with intact ventricular septum. In the former group, both relative hypovascularity and hypervascularity of the whole left lung or its upper lobe occurred with equal frequency while in pulmonary valve stenosis relative hypervascularity on the left side was the single disparity encountered. The variations in the internal calibers of the right and left main pulmonary arteries in Fallot's anomaly were of the same degree as those noted in the vasculature of the lungs while in pulmonary valve stenosis no such correlation was recorded. In both heart lesions inequality of the vasculature had its counterpart on the venous side.

No evidence was recorded to substantiate the hypothesis that the orientation of the right ventricular outflow tract and main pulmonary artery determined the discrepancy in the appearance of the vasculature of the lungs, nor had the direction of the systolic jet in the main pulmonary artery any obvious significance. The findings would indicate that the disparity of vascularity of the left and rights lungs in Fallot's anomaly and in simple pulmonary valve stenosis represents an associated anatomical abnormality and is not a secondary effect of the altered haemodynamics.

SUMMARY

The hypothesis that unequal vascularity of the lungs in Fallot's anomaly and pulmonary valve stenosis with an intact ventricular septum may be determined by the direction of the

pulmonary artery jet as well as by the orientation of the right ventricular outflow tract and the pulmonary artery was not substantiated in the present investigation The findings present ed u est that structural rather than haemodynamic factors may be of greater importance

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PATTINSON J N and EMANUEL R W The aorta and pulmonary arteries in Fallot s tetralogy Brit Heart J 19 (1957) 201

PORSTMANN W IL SALIAB R A and DAVID H Pseudoaplasia of the right pulmonary artery associated with right sided aortic arch Brit Heart J 29 (1967) 527

SCHISMANOV N Zur Hämodynamik des Lungenkreislaufs beim Ductus arteriosus persistens (DAP) Ein neues rontgenkymographisches Phanomen Über die Genese der pulmonalen Hypertonie beim DAP Z Kreisl Forsch 57 (1968) 46

WILSON W J and AMPLATZ K Unequal vascularity in tetralogy of Fallot Amer J Roentgenol 100 (1967) 318

WHITLEY J E RUDHE U and HERZENBERG H Decreased left lung vascularity in congenital left to right shunts Acta radiol Diagnosis 1 (1963), 1125

FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN) SERAFIMER LASARETTET, STOCKHOLM SWEDEN

CONTROL OF A TOMOGRAPHIC SYSTEM

by

OVE MATTSSON

The increased demands on tomographic apparatus for precision and good image quality necessitate increased knowledge of control methods to enable extension and improvements. A test object commonly used for determining the resolution of detail is the wire phantom. This may take various forms, but the one used by the author has three or four parallel smooth wires of diameters down to 0.1 mm arranged obliquely. The movement of the tube in a tomographic system will produce a potential 'space image' of the object in the image plane. This is a three dimensional phenomenon, the existence of which was pointed out by MARSTRANDER (1954). This potential 'space image' may be recorded in a roentgenographic film in different ways.

A wire may be said to be a cylinder. The conditions first to be discussed presume the cylinder to be horizontal and the tomographic plane to pass through its centre. Different directions of the roentgen beam are represented in Fig. 1. The parts of the cylinder depicted will be limited and will form the tangential zones (EDHOLM 1960) indicated by dense lines. The space image obtained consists of an unirradiated three dimensional zone, a cross-section of which is roughly rhombic with two acute angled corners and two curved sides, the latter corresponding to the tangential zones; in these a true contour can be obtained tomographically.

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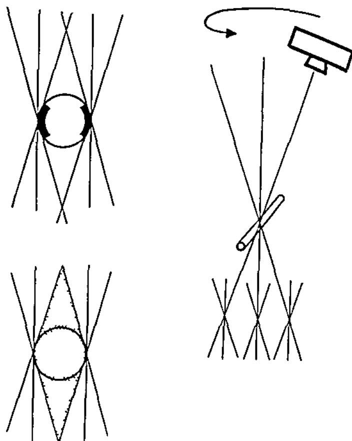


Fig 1 The tomographic conditions in the depiction of a cylinder Different directions of the roentgen beam will create a space image (seen in cross sections) The tangential zones are indicated by the thick black areas)

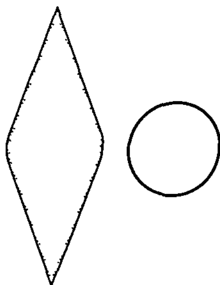


Fig 2 Representation of the appearance in principle of the space image and *the cylindrical object* (both seen in cross sections)

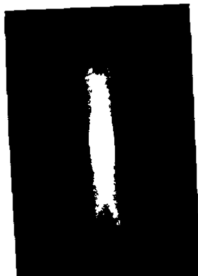
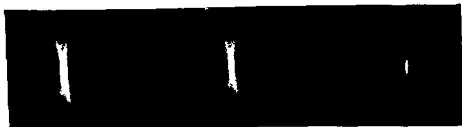


Fig 3 Magnified tomographic image of a wire arranged obliquely (top) and tomographic test with wires of diameters down to 0 2 mm (below)



The principle of a space image of a cylinder with an arbitrary tomographic system is presented in Fig 2 together with the cylindrical test object to enable a comparison between them each being depicted in cross-section All the beams are viewed in one plane This suffices for the discussion since beam movements in parallel with the cylinder do not alter the image The film may be positioned within the unirradiated zone (the space image) and thus arranged to record the plane desired The conditions when the cylinder is arranged obliquely may be derived from this figure with reasonable approximation The space image of the oblique cylinder will of course be oblique and as the film is horizontal, an oblique section of the potential space image will be recorded This will correspond to a cross-section of increased length although of the same structure

Blurred contours often with irregularities explained by the pattern of movement are produced outside the space image A magnified roentgenographic image of a thin wire is shown in the upper image in Fig 3 Usually a few wires

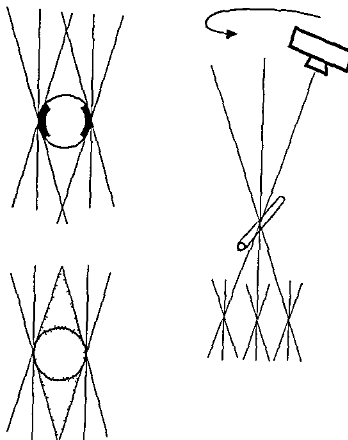


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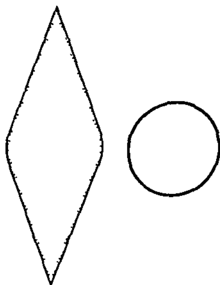


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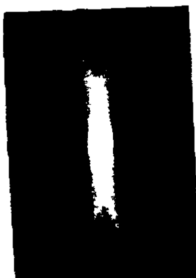


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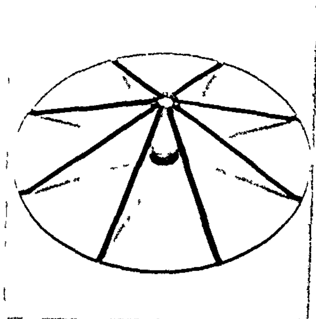


Fig 4 A tomographic test object

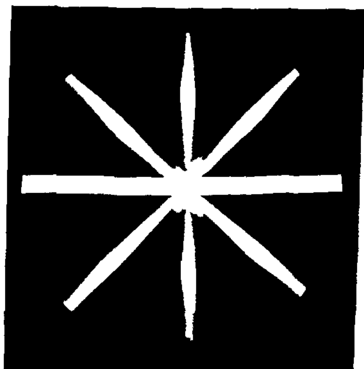


Fig 5 Linear tomogram with the test object Various degrees of blurring for different contours depending upon the orientation



Fig 6 Irregularity of blurring in certain types of tomographic movement recorded with the test object (left) and with the wire test (right) Both represent hypocycloid motion

are used as in the lower image in Fig 3 The wires conveniently arranged in a small frame are tilted 30 or 40 during the exposure The test can be accepted if a well defined figure as described above is obtained It is sufficient even for complicated tomographic systems to make the wire test in two directions with 90 between each

Special equipment consisting of thin metal bars arranged in the form of a star was constructed for the purpose of studying the true definition obtainable in the tomographic layer and the type of blurring adjacent to it with special reference to the orientation of the contours (Fig 4) It is well known that a linear tomographic system for example produces good blurring of certain contours but practically none of others. An ellipsoid pattern of movement on the other hand produces different types of blurring for the various contours

These phenomena are closely associated with what may be called layer thickness The type of blurring affords a good impression of the capability of the apparatus in use as demonstrated with the equipment with the metal bars.

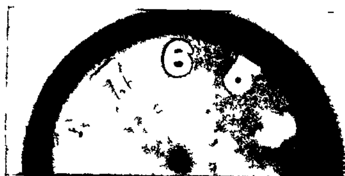


Fig 7

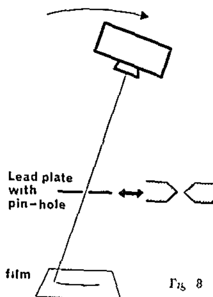


Fig 8

Fig 7 Phantom with lead letters at different levels

Fig 8 By means of pinhole in the object plane the tube movement is recorded on a cassette placed underneath

Knowledge of the gradient of the bars will enable the layer thickness to be estimated, and many may consider this factor a quality sign of a tomograph but the expression layer thickness is in fact an irrational one and cannot be accepted without reservation The matter is more complicated than generally believed In ellipsoid tomography, for instance the layer thickness is not constant but varies with the orientation of the contour continuously between two borderline values In linear tomography it alters gradually from infinity to a minimum (cf Fig 5) It is also inconstant in hypocycloid tomography but has certain minima that also depend upon the actual orientation of the contour An overall evaluation of a tomographic system by such an inaccurate method is not very recommendable but may be of interest as it spotlights the various degrees of blurring obtained with a given system It thus represents the tomographic quality for certain contours positioned arbitrarily Both the well defined and blurred parts of the image produced with this phantom afford information and it is possible closely to observe the blurring of a contour during the movement of the tomographic system Each radiologist must direct the results from the phantom tests to the work in hand and select a type of movement suitable for the object to be examined

It should be pointed out that the turnings in the tomographic system (where the beam changes direction when the tube has completed a turn) will produce irregularities in blurring Such irregularities for instance in hypocycloid movement, are particularly well seen with the test star but they are also observable with the test wires, as illustrated in Fig 6



Fig 9 The irregularity of the curve indicates mechanical instability

A representation of the level of the tomographic plane may be obtained with a simple arrangement consisting of an acrylic plate in which thin metal letters or numbers are arranged at 2 mm intervals like steps in a spiral staircase Similar systems have been used for many years (Fig 7) It will be noted that the blurred letters permit an evaluation of the tomographic function It must always be kept in mind that the blurring is the movement of the sharp image corresponding to the tube path

The tests described allow of an easy evaluation of tomographic systems The level of the tomographic plane the definition obtained and the type of blurring obtained are sufficient for practical needs Comparisons may of course also be made between various types of motion and different apparatus Unsatisfactory definition may be due to factors connected with the mechanical system or the focus. In such an event as well as in all situations in which the stability is in doubt it will be neccessary to make complementary tests

Good definition in the tomographic plane produced by accuracy of the projection is theoretically based on the simultaneous movement of the focus and the film in paths so arranged that a ray from the focus through an object detail always hits the same point in the film A tomograph is thus made up of a much more complicated mechanical system than any other roentgen apparatus. The demands on the mechanical construction are high and an inaccuracy of 0 1 mm may impair the results A regular check of the installation and a few simple tests will enable a control of the accuracy

The main principle in such checking is the use of a suitably adapted pinhole which enables a record of the tomographic path to be obtained

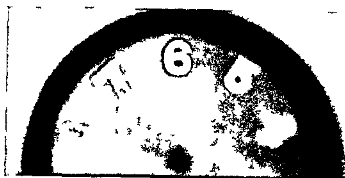


Fig 7

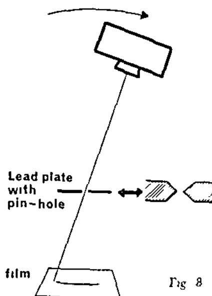


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Fig 12 Adjustment of the exposure time to a higher value than that corresponding to the tomographic cycle produced double exposure Different types of this phenomenon are depicted

whole It should be kept in mind that the tube a heavy component of the system, often suspended by a movable arm may cause more instability than the cassette holder which moves more slowly and contains fewer heavy parts

If the pinhole is located above the tomographic plane and at a sufficient distance from it the beam through it will trace a contour in the film lying in the moving cassette holder This will represent the tomographic path The central ray will then not be used and this may influence the result Irregularities in the focal spot sometimes appear when a peripheral beam is employed The principle however usually renders a satisfactory result This method unveils irregularities of tube movement in relation to those of the cassette i e deviations from the calculated path that are not neutralized in the system itself The outcome of this type of test is presented in Fig 10 where the tomographic path has been interrupted It is the result of a short exposure which does not correspond to the whole tomographic cycle

The pinhole to be used for these studies must be made in a special way as it has to transmit variously directed beams The pinhole described and standardized for conventional focal studies (KUNTKES 1957) consists of a hole with parallel sides but with a restriction in the centre which will cut off the beam if it should not be wholly or approximately at right angles to the image plane A specially



Fig 13 Variation in focal size with milliamperage low value 25 mA (left) and high value 100 mA (right)

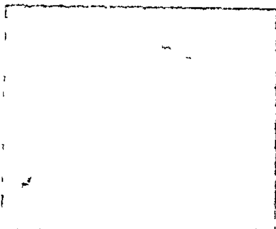


Fig 10 Incomplete tomographic cycle indicated by the pinhole test The exposures has not been of sufficient duration

Two possibilities exist A fixed pinhole may be used, and a stationary cassette is placed below it, the cassette is arranged so as to depict the beam projected in a thin line representing the movement of the tube The pinhole should be situated in the object plane and the central ray should be employed (Fig 8) Many interesting observations may be made by a study of the records so obtained An irregularity, in the start of the movement, for instance, will indicate serious instability Such a phenomenon is depicted in Fig 9 where irregular and smooth curves are presented together, in the actual tomogram, a marked reduction in definition occurred

It may be pointed out, against the method described that the irregularities of the movements of the tube and the cassette may sometimes cancel out The test must therefore be performed in a way to permit a recording of the total deviation from regularity, be it caused by the tube itself or by the system as a

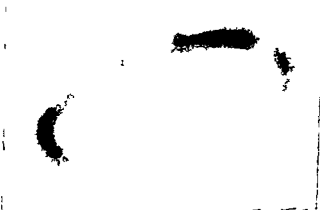


Fig 11 At constant tube speed a uniform density will be produced with the pinhole test A moderate reduction in speed at the turnings in an ellipsoid tomographic system leads to increased exposure a region of double exposure can be observed

It is not only necessary for the mechanical system to have a stable action without deviations from the path selected but constant speed and exposure intensity must also exist if optimal tomographic results are to be obtained

Another type of pinhole may be used to study the exposure during the tomographic cycle which is in fact a measure of exposure intensity related to speed This has a diameter of about 0 25 inches (about 6 4 mm) and when arranged in a way similar to the pinhole described above gives a band shaped exposure indicating the exposure intensity Compared with the small pinhole, this system offers a superior means of judging the exposure which may now also be determined densitometrically A more accurate estimation will sometimes be necessary for electrical adjustments

It is possible to recognize irregularities in density with the naked eye Two examples will be given The speed of a tomograph is often reduced temporarily while the heavy masses of the system are turning at the ends of an ellipsoidal figure where the radius of the curve reaches its minimum A relative increase in exposure often occurs (Fig 11) When the exposure time is adjusted to a value higher than that corresponding to a full tomographic cycle a kind of double exposure will appear Such a phenomenon may be observed in Figs 11 and 12

A study of the focus may be of some interest This is preferably performed with a standardized pinhole plate 70 μ or 30 μ in diameter as described by KUNTKE The test like all conventional tube tests is made with a fixed tube A variation in focal size sometimes accompanies the milliampere value this observation has explained the reduction in definition that was obtained with a certain change in milliamperage Two pinhole images varying in size and shape with the milliamperage are presented in Fig 13

Other reasons for a study of the focal spot exist A considerable oversize in foci is not uncommon (KEMP & NICHOLS 1958) and tubes labelled 0 6 mm may have focal sizes of about 1 0 mm $\times$ 0 9 mm i e a diagonal measurement of about 1 3 mm A check of the focal spot is important and must be made if the definition to be expected with a certain apparatus is to be known The tube in some tomographic systems revolves during the cycle which means that the diagonal measurement will function as the true focal measurement This may be unfavourable compared with a similar non moving focus the total width of which at least in some directions will not reach the same value The matter of focus is usually more critical in tomography than in conventional roentgenography The reason for this is that a moderate degree of magnification and an increased object to-film distance practically always exists in the former The geometric conditions are then more critical than otherwise and the focal spot itself is the dominating factor

It is important to appreciate that different casettes may have various levels

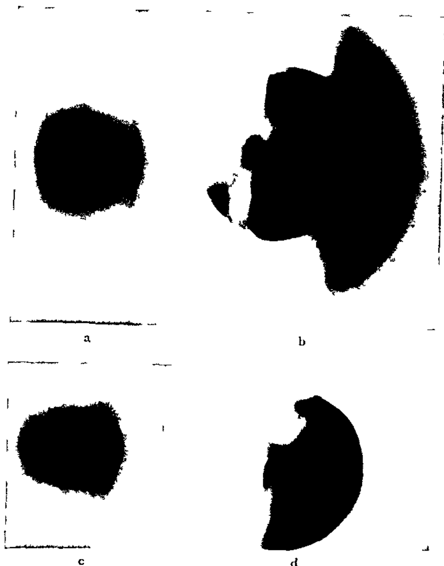


Fig 14 The off focus radiation in the pinhole image (a) produces a large amount of unnecessary radiation apparent in the tomogram (b) as a wide zone of density Off focus radiation has been reduced by a small close to focus diaphragm (c) and the tomogram is improved (d)

constructed wide angle pinhole was used to produce a width of beam approximately constant in spite of its direction Funnel shaped depressions on the two sides of the lead plate meet in a narrow hole, the total shape of the passage is not unlike a sandglass With this system the diameter of the beam will not be changed by a moderate variation in the inclination of the beam A narrow beam of constant width is necessary for a study of irregularities in the path

schrieben Die mechanischen Anforderungen auf einen zuverlasslichen Tomograph sind hoch da die kleinsten Ungenauigkeiten die Resultate beeintrachtigen. Der Verfasser meint, dass die Rontgenologen den Tomograph selbst prufen und kontrollieren sollten.

RÉSUMÉ

L auteur etudie les objets tests et les methodes de controle des appareils tomographiques Il decrit un fantome special en fil metallique pour determiner la resolution d image La construction mecanique des tomographes doit obeir a des exigences tres severes et la plus petite imprecision peut nuire a la qualite des resultats L auteur pense que les essais et les controles des tomographes devraient etre faits par les radiologistes qui les utilisent

REFERENCES

EDHOLM P The tomogram its formation and content Acta radiol (1960) Suppl No 193

KEMP P H and NICHOLS A F Focal spot sizes Brit J Radiol 31 (1958) 486

KUNTKE A. H G On the determination of roentgen tube focal spot sizes by pin hole camera roentgenography Acta radiol 57 (1957) 55

MARSTRANDER F Fundamental problems in connection with image formation in tomography Acta radiol (1954) Suppl No 116

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PEYSER L. F Diagnostic X ray beam collimation Cathode Press 23 (1966) 36

of film plane Such conditions may cause serious errors when a separation of tomographic layers down to 2 mm is necessary A standardization of cassettes with a much higher degree of precision seems to be required

The secondary radiation appearing in tomography is generally taken care of by grids, or is reduced by the increased object to-film distance A type of radiation that will act not unlike secondary radiation is off focus radiation This emanates from the tube itself, especially from the neighbourhood of the focus — the focal disc — and will not produce any image Coming from the tube it is not reduced by the increased object to film distance and it reduces contrast in the same way as the secondary rays This matter was discussed by the present author in 1955 Most tomographic examinations are made with rather small image sizes so that the possibilities for a more efficient reduction of the off focus radiation will then exist The effect obtained by a small close to-focus diaphragm mounted at the tube window is demonstrated in Fig 14

A tomographic image in itself, representing a thin section of the body, will generally present low contrast, and each addition of foreign rays is undesirable *The off focus radiation can be recorded with a fairly wide pinhole in the central* beam and moderate overexposure (Fig 14, a and c)

All human test objects involve inconstants, such as involuntary movement and anatomical variations from subject to subject, and in this respect phantoms are superior This does not mean that the true results obtainable with a tomograph will always be applicable to the clinical sector since there are many factors in a human subject that may influence the proper choice of a system

The test objects and the methods now described of checking the apparatus are simple tools for examining some of the fundamental functions It is suggested that all tomographs should be controlled by their operators, the radiologists, not only on delivery but also regularly, especially when the clinical findings indicate that such a test be needed

SUMMARY

Test objects and methods of checking tomographic apparatus are discussed A special wire phantom for determining the resolution is described The demands on the mechanical construction of tomographs are high and the slightest inaccuracy may impair the results It is suggested that the testing and control of tomographs should be performed by the radiologists who use them

ZUSAMMENFASSUNG

Methoden zur Prufung von Tomographie Apparatur mittels Testobjekten werden diskutiert Ein besonderes Drahtphantom zur Bestimmung des Auflosungsvermogens wird be

schrieben Die mechanischen Anforderungen auf einen zuverlasslichen Tomograph sind hoch da die kleinsten Ungenauigkeiten die Resultate beeintrachtigen. Der Verfasser meint, dass die Rontgenologen den Tomograph selbst prufen und kontrollieren sollten

RÉSUMÉ

L auteur etudie les objets tests et les methodes de controle des appareils tomographiques Il decrit un fantome special en fil metallique pour determiner la résolution d image. La construction mécanique des tomographes doit obeir a des exigences tres severes et la plus petite imprécision peut nuire a la qualite des resultats L auteur pense que les essais et les controles des tomographes devraient etre faits par les radiologistes qui les utilisent

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PEYSER L F Diagnostic X ray beam collimation Cathode Press 23 (1966) 36

FROM THE ROENTGEN DEPARTMENT (DIRECTOR O. MATTSSON), ERSTA SJUKHUS, STOCKHOLM, SWEDEN

AREOMETER FOR ESTIMATING THE CONCENTRATION OF MODERN BARIUM MEALS

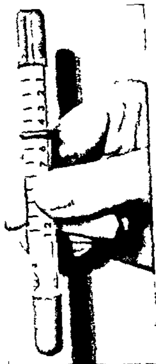
by

OVE MATTSSON

By the introduction of a new type of barium contrast medium of low viscosity but high specific gravity, the areometer of limited range that was previously used for approximate estimations (MATTSSON 1953) has become inadequate and thus had to be altered.

The expression high density contrast media, which has appeared now and then in the literature, is physically incorrect. The factor density in reference to the roentgenographic depiction, is correlated to the amount of heavy barium sulphate per unit of volume and is thus physically proved. A water suspension with a certain amount of roentgen ray absorbing substance may however possess different physical properties depending on the hydratisation effect. This effect refers to the ability of each colloidal particle to absorb water molecules, with formation of larger aggregates. It is due to the addition of small amounts of specific substances. A barium sulphate water mixture, of a given ray absorbing capacity, can be modified from high to low viscosity — from that of a tooth paste to a watery liquid — by addition of very small amounts of specific substances. The true amount of the absorbing substance is not changed, however.

Submitted for publication 10 March 1969



The new areometer is small and handy an adjustable ring facilitating its use

With earlier conventional barium meal mix tures it was possible to reach a high density al though not without a simultaneous high viscosity perhaps that of a paste The new principle allows low viscosity to be maintained together with a high concentration of contrast producing substances (EMBRING & MATTSSON 1956)

The additive components for obtaining low viscosity have also been utilized to enable ad dition of food to a barium water mixture a stabilized and standardized meal with physiologic properties was thus developed (MATTSSON et coll 1959 EMBRING & MATTSSON 1956) A suitably low viscosity can be maintained in spite of the considerable amount of added nutrients and the mixture still has a density of the order of magnitude of ordinary meals and a stability not available in any other way

The new areometer is similar to the one pre viously marketed for conventional values of spec ific gravity The instrument is adapted for values of specific gravity of 1 1 to 2 2 but in design differs little from the earlier model Theoretically still higher values of specific gravity may be en countered but then practical difficulties may appear In spite of the low viscosity a high intrinsic viscosity or a kind of internal friction will occur in extremely dense suspensions caused by the heavy mass of the suspended material This phenomenon may interfere with the function of the areometer in spite of its smooth streamlined design The instrument is shown in the accompanying figure

The areometer will be manufactured by Svenska AB Philips Stockholm Sweden.

SUMMARY

A new areometer for estimation of the specific gravity of barium contrast media is de scribed Its extended range enables controls to be made of barium meals of densities higher than those within the range of the earlier instrument

ZUSAMMENFASSUNG

Ein neuer Araometer zur Bestimmung des spezifischen Gewichtes von Bariummischungen wird beschrieben Das Instrument hat einem erweiterten Messbereich der es ermoglicht auch hohere Konzentrationen als bisher zu messen

RÉSUMÉ

L'auteur décrit un nouvel aréomètre pour mesurer les poids spécifique des moyens de contraste barytés. Son domaine de mesures étendu permet de contrôler des densités plus élevées qu'avec les instruments existants.

REFERENCES

EMBRING G.: Synpunkter på tillverkningen av bariumkontrastmedel (in Swedish). Nord. Med. 56 (1956), 1183.

— and MATTSON O.: An improved physiologic contrast medium for the alimentary tract. Acta radiol. Diagnosis 4 (1966), 105.

— — Barium contrast agents. Acta radiol. Diagnosis 7 (1968), 245.

MATTSSON O.: A simple method of ensuring correct concentration of barium contrast media. Acta radiol. 39 (1953), 501.

— Bariumkontrastmedlens egenskaper ur röntgendiagnostisk synpunkt. En jämförande studie av olika typer av kompositioner (in Swedish). Nord. Med. 56 (1956), 1182.

— LAGERLÖF H. and PERMAN G.: Barium contrast medium with physiological properties — Some experiences. Abstracts from the IX. Intern. Congr. Radiology, Munich 1959.

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RÖNTGEN AND THE NOBEL PRIZE

With notes from his correspondence with Svante Arrhenius

by

FOLKE KNUTSSON

The first distribution of Nobel prizes took place in Stockholm on December 10th 1901

That year the Nobel Prize in Physics was to be awarded to Wilhelm Conrad Röntgen according to a decision made at the Meeting of the Swedish Royal Academy of Sciences on November 12th 1901 Röntgen on being notified of this decision wrote to Svante Arrhenius with whom he was already acquainted Arrhenius was a member of the Nobel Committee for Physics, and Röntgen was anxious to obtain information concerning various matters connected with the award The subsequent correspondence has hitherto received *no attention* although it may be considered of interest in that it throws some light on Röntgen's personality

Röntgen in a letter dated November 17th 1901, was *notified officially* by the Secretary of the Swedish Royal Academy of Sciences that he had been awarded the Nobel Prize He was also told of the Academy's wish that the decision be kept secret until the *presentation* of the prize on December 10th, which was to be the Nobel *Foundation's* Commemoration Day of Nobel's death and that he

From the Department of Diagnostic Radiology (*Director Prof H Lodin*) the University Hospital Uppsala Sweden



Swedish stamp issued in 1961 in commemoration of the Nobel Prize Award in 1901

was desired to be present personally to receive the prize. Röntgen was further notified of the wish, according to the statutes, that if possible the recipient should deliver a public lecture on a subject associated with the work for which he was being rewarded.

Röntgen, in his letter of reply to the Academy, which was dated November 24th, 1901, and which had been drafted on the reverse side of the letter of notification, expressed his great surprise at having been awarded the prize and said that he was still trying to accustom himself to the idea. He hoped he would soon have the opportunity of expressing his thanks to the Academy in person and raised the question of the date of his Nobel lecture. He stated that it might possibly be in the middle of December although this would not be easy and that he would prefer February or May.

Röntgen had clearly before he received the official letter been notified of the Academy's decision, probably by telegram, for on November 16th he sent a private letter to Arrhenius, thanking him for his good wishes. He expressed his great pleasure at the news of the award. "A saga has come true," he wrote, "after receiving your letter this idea is constantly in my mind." He promised to do his very best to attend the Prize Ceremony and hoped that his request for leave of absence would not be refused as he had never before made such an application. He also asked if Arrhenius would be kind enough to advise him as to how he should best arrange his journey. He did not dare to ask advice from any of his acquaintances in Germany for fear of arousing suspicion. Arrhenius in his letter of reply of November 21st listed the train and boat connections with Sweden and gave details of the departure and arrival times from Munich via Berlin and Sassnitz and via Warnemünde. He advised Röntgen to give his lecture in connection with his attendance at the ceremony and thereby save himself an extra journey.

Röntgen enjoyed travelling. He liked to make journeys to different places in Germany, he had visited Switzerland and on several occasions travelled in Italy. It is obvious, however, that he was disinclined to make the journey to Stockholm

München 16 Nov 1901

Sehr verehrter Herr College!

Ein Märchen ist zur Wirklichkeit geworden! Dieser Gedanke kommt mir seit dem Empfang Ihrer Zeilen nicht aus dem Kopf. Ich weiss noch nicht, was ich zu Allem sagen soll. Doch vorerst nehmen Sie meinen verbindlichsten Dank für Ihre lieben freundlichen Worte.

Dass ich bei einer solchen Gelegenheit gern alles thun möchte, um allen Anforderungen und Wünschen gerecht zu werden ist ja selbstverständlich und so würde ich auch gern zur Preisvertheilung persönlich erscheinen wenn ich es möglich machen könnte. Ich brauchte dazu Urlaub,

der mir wahrscheinlich wohl nicht verweigert
werden würde, weil ich noch niemals um einen
solchen ersucht habe. Ob ich, wie Sie meinen,
einen Vortrag bald nach der Preisvertheilung
halten würde, kann ich noch nicht sagen. –
Um einen guten Plan machen zu können, muss
ich wissen, in welcher Zeit eine Reise nach
Stockholm sich ausführen liesse. Nun war
ich leider niemals in Schweden, und ich darf
auch, um keinen Verdacht zu erregen, keinen
Bekannten hier nach den besten Reiserouten
etc. fragen. Würden Sie wohl die grosse Liebens-
würdigkeit haben mir kurz mitzutheilen,
wie man am besten reist, und wieviel Zeit
für eine Hinreise ungefähr nöthig ist?
Ich wäre Ihnen für eine solche Mittheilung
ausserordentlich dankbar.

Mit herzlichsten Grüssen

Ihr ergebenster

W C Röntgen

Translation of letter from Rontgen to Arrhenius dated Munich 16 November 1901

My Esteemed Colleague

A saga has come true This thought has been constantly in my mind since I received your letter I do not know what to say about it all First I want you to accept my sincere thanks for your very kind words

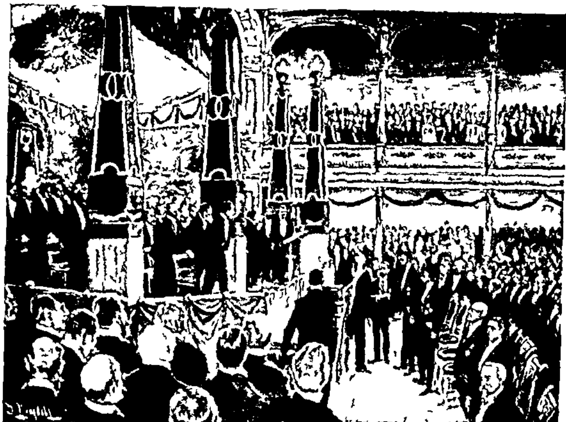
It is obvious that on such an occasion I will do all I can to fulfil all demands and desires I would also very much like to be present personally at the Prize Award Ceremony if this is possible For that I will need leave of absence which will probably not be denied me since I have never before applied for such leave

Whether I will give a lecture immediately after the prize distribution as you suggest I cannot say as yet Before I can make any definite plans I will have to know the mo t suitable time for making the journey to Stockholm Unfortunately I have never been to Sweden and for fear of arousing suspicions I cannot ask anyone here about the best route Would you be so very kind as to let me know briefly the be t way of travelling and how long it would take? I should be extremely grateful for this information

With my best greetings
Yours sincerely
W C Rontgen

to attend the Nobel Ceremony and that he had even hinted at this Thus on December 6th 1901 he had received two telegrams simultaneously from Stock holm One was from the Prize Distribution Committee stating that the German Ambassador had gone to Norway and that Rontgen could not thus be certain of being represented wherefore he was earnestly entreated to be present The other telegram came from Arrhenius with the news that the two other Science Laureates would attend It was clearly not until he had received this information that Rontgen decided to make the journey and his application for leave of absence was dated that same day It read since the prize is of extreme value and confers great honour upon me I consider myself forced to fulfil the desire of the Swedish Royal Academy of Sciences though with no light heart This is further proof of how he was dreading the journey

Rontgen arrived in the Swedish capital on the morning of the day before the prize distribution was to take place On the same day he wrote to his wife describing his journey He had travelled by boat from Sassnitz to Trelleborg The sea was rough and the waves swept over the ship so that there was no question of being out in the open air I stood it for two hours but then I had to give in and spent the next two hours in the customary way Rontgen was clearly in a poor condition and when reaching Malmo by train had considered remaining there although he finally decided to continue He felt better during the train



The Nobel Ceremony in the Great Hall of the Academy of Music Stockholm on December 10th 1901 Rontgen is receiving his prize from the hands of the Swedish Crown Prince (Drawing by D Ljungdahl in the magazine Idun)

journey On arrival in Stockholm he was to stay at the Grand Hotel and there he was met by Arrhenius

The ceremony took place in the Great Hall of the Swedish Academy of Music on December 10th, 1901 five years to the day after the death of Alfred Nobel Rontgen was praised in a long speech in which an account was given of the discovery for which he was now being rewarded and thereafter he received the prize from the hands of the Crown Prince of Sweden

At the subsequent Nobel Banquet Rontgen delivered an eloquent speech of thanks, the substance of which was evident from an article in the daily press

Rontgen replied with a brilliant speech which was received with great applause Ever since childhood, he said he had been less conversant with Greek than with Scandinavian mythology For him, Scandinavian mythology had always held something romantic and adventurous, and now he himself was experiencing a new romantic Scandinavian adventure, which seemed to him like a dream

but which was nevertheless a joyful reality That day a descendant of a line of kings beloved by their people had presented magnificent prizes given by a son of Sweden and at the suggestion of Swedish scientists In this noble collaboration between the Royal Family the people and scientists the speaker saw something characteristically and honourably Scandinavian He wanted to admit openly that he had never imagined that he would receive this prize but now that it had been presented to him he wished to declare that he intended to use it in the pirit of the founder for the altruistic promotion of further scientific development

Rontgen left the capital on the day after the Nobel festivities He obviously felt highly honoured and proud of his prize In a letter dated December 18th, 1901 to his friend Boveri he said that the Nobel Prize had given him very great pleasure and I also against my custom, travelled to the appointed place to receive it Since I only allowed a day and a half I managed to stand the celebrations I must say the Swedes understand how to arrange these occasions in a imple and therefore honourable way

The Undelivered Nobel Lecture

As early as November 16th 1901 Rontgen in a letter to Arrhenius raised the question of the lecture which was to follow his receipt of the prize and he returned to this matter in his subsequent correspondence He did not give a lecture immediately after the Prize Award Ceremony and in one of his letters he stated that this was due to the circumstances prevailing at his University, which he was unable to alter and which did not affect von Behring or van t Hoff who were completely free men The nature of these circumstances was not revealed in the correspondence however

When the six month period of grace for the Nobel Lecture began to expire he raised the question with Arrhenius in a letter dated April 17th 1902 as to a suitable date He suggested Whitsun week i e May 20th to 24th but wondered at the same time whether the Royal Academy of Sciences might not allow him to come in July or August As a reason for this he stated that he wanted to utilize his vacation for the journey and that he did not wish to apply again for leave of absence and interrupt his lecturing duties After a few days he received a favourable reply from Arrhenius and in his response of April 26th he expressed his pleasure at the information that his lecture would be accepted even in September or October You have freed me from a nightmare he said I was finding it increasingly difficult to get used to the idea of travelling to Stockholm in the middle of May to give my lecture

Rontgen s collaborator and good friend Zehnder was well aware of his anxiety at the thought of his Nobel Lecture in Stockholm In a letter dated August 15th

GEHEIMRATH RONTGEN MUNCHEN 16 Okt 1902

Verehrter und lieber Herr College!

Das war eine plötzliche Wendung der guten Mittheilung in seinen Plänen entsteht! Ich war vollständig reisefertig und meine Frau und ich wollten heute morgen abreisen, auch in dem Fall dass noch keine Antwort auf meine Anfrage bezüglich des Vortrag[e]s hier eingetroffen wäre — das Nachsenden nach Berlin, resp. Kopenhagen war bereits in Auftrag gegeben — als ein Brief von Prof. Hasselberg eintraf der zum Schluss den Satz enthielt: „Dies Alles natürlich nur wenn Sie den Vortrag halten wollen was nach den Statuten allerdings erwünscht aber nicht absolut nothwendig ist." Diese sehr dankenswerthe Mittheilung vom Vorsitzenden des Nobel Comitees für Physik — also von officieller Seite — veranlasste mich folgende Depesche an Sie zu richten: „Nach Ihrem heute empfangenen Brief ist Vortrag statutengemäss wohl erwünscht aber nicht absolut nothwendig. Unter diesen Umständen bin ich sehr geneigt nicht zu reisen. Doch möchte ich noch Ihre Meinung darüber erfahren ob Nobelcomité mein Fernbleiben übel nehmen könnte." Meine Abreise wurde auf alle Fälle um einen Tag hinausgeschoben. Heute erhielt ich die Antwort „Vielleicht besser zu kommen"! Daraufhin entschloss ich mich hier zu bleiben und ich hoffe — und glaube auch — dass Sie mir diesen Entschluss nicht verdenken werden. Sie wissen aus unserer Correspondenz das

Genüge hier erblicke ich einer der Arbeit gehabt habe meiner Verpflichtung — als solche fasste ich den Paragraphen der Nobel statuten auf, bis ich dessen Auslegung eines anderen belehrt wurde — nachzukommen, und dass ich auch mit keinem Wort je darauf hin gedeutet hatte als ob nur die Erfüllung meiner Pflicht ein Mühe oder ein Opfer wäre. Dass ich den Vortrag nicht gleich nach der Preisverteilung halten konnte lag an meinen Universitätsverhältnissen die ich nicht ändern konnte und die für Behring und van 't Hoff als vollständig freie Männer nicht massgebend waren.

Ich erwähne dieses Alles damit die Herren vom Nobel comite und vor allen Dingen Sie, der mir gegenüber so besonders freundlich war keine Veranlassung haben sollen mit mir unzufrieden zu sein. Sie werden es mir auch wohl nicht verdenken dass ich mich darauf gestützt habe nachdem mir bekannt geworden war dass eine recht-liche Verpflichtung nicht bestände. Habe ich doch auch die Be-fürchtung nicht ganz unterdrücken können dass unter den er-wähnten Umständen nicht der Eine oder der Andere mit vollem Recht sich gedacht haben würde, der Röntgen hat wohl gern den Vortrag halten wollen denn sonst hätte er die grosse Reise nicht gemacht und so viel Zeit geopfert.

Haben Sie vielen Dank für alle Freundlichkeit die Sie in dieser Angelegenheit erwiesen haben. Ich schliesse in der Hoffnung dass wir uns bald einmal wieder sehen.

Ihr ganz ergebener

W C Röntgen

GEHEIMRATH RONTGEN MUNCHEN 16 Oct 1902

Verehrter und lieber Herr College!

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Ihr ganz ergebener

W C Röntgen

Translation of letter from Rontgen to Arrhenius dated Munich 10 October 1902

My Esteemed and Dear Colleague,

A sudden change occurred in my plans yesterday afternoon I was absolutely ready for the journey and my *wife and I* were to have left this morning even if no answer had come to my question about the time for *delivering the lecture I* had arranged for my mail to be sent on to Berlin or Copenhagen Then a letter from Professor Hasselberg arrived which *ended* with the *following* sentence All this obviously only if you wish to give the lecture which *according to the* regulations is certainly desirable but not absolutely necessary This very acceptable message from the Chairman of the Nobel Committee for Physics i e from *official quarter* gave me reason to send him the following telegram In your letter received *today you* state that according to the regulations my lecture is desirable but not absolutely necessary Under these circumstances I am very reluctant to make the journey but I would *like* your opinion as to whether the Nobel Committee will be offended if I do not come My *departure* was thus postponed for a day Today I received the reply Perhaps best to come I decided nevertheless to remain here and I hope and also believe that you will not reproach me for my decision You will be well aware from our correspondence how I have *honestly* intended to fulfil my obligation I interpreted the paragraph in the Nobel Statutes as such until I received different information from Hasselberg You also know that I have not with one word intimated that it would be an effort or a sacrifice to fulfil my obligation The fact that I was unable to give the lecture immediately after the prize distribution was due to our university conditions which I could not alter but which do not apply for Behring or van t Hoff who are completely free men

I mention all this so that the gentlemen of the Nobel Committee and especially you who have been particularly kind towards me will not be dissatisfied with me I hope you will not reproach me for withdrawing when it became known to me there was no actual obligation I cannot rid myself of the suspicion however that some might not think Rontgen he must surely have wanted to give the lecture otherwise he would not have made the long journey and given up so much of his time

With many thanks for all the kindness you have shown me in this matter I end with the hope that we shall soon meet again

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Zehnder offered to accompany Rontgen on his journey and to assist with the experiments which Rontgen was considering including, and thus make the presentation easier for him In a letter of reply written on September 2nd, Rontgen expressed his sincere thanks but even then made no definite plans for the lecture and therefore gave Zehnder neither a positive nor negative answer

In a letter to the Nobel Foundation dated October 2nd Rontgen inquired about a suitable day at the end of the month for the lecture He had then clearly decided to make the journey, and in a letter to Arrhenius dated October 8th

expressed certain wishes in connection with the lecture He intended to project some slides and stated his requirements concerning the illumination and lens of the projector He added I wish all this were over It is the only public lecture that I have been requested to give and I have stage fright so to speak

Rontgen made preparations for leaving Munich on October 10th to be accompanied by his wife, but on October 9th he received a letter dated October 6th from the Chairman of the Nobel Committee in which he was informed that the 17th 20th or 21st of October would be suitable dates for the lecture He was requested to send a telegraphic reply The end of the letter read "this applies obviously only if you wish to give the lecture which according to the regulations is desirable but not absolutely necessary Rontgen grasped at this official intimation and now perceived a formal possibility of withdrawing Much earlier in his application for leave of absence he had declared that it was not with a light heart that he was preparing to travel to Stockholm In view of his apparent disinclination to make the journey and the necessary public appearance, it was probably with a great relief that he found a reason for not going He therefore telegraphed that he was very disinclined to travel but that he would first very much like to know whether the Nobel Committee would be offended if he did not give the lecture The telegram which he received in reply ran Perhaps best to come Nevertheless Rontgen decided to remain at home and telegraphed both to the Nobel Committee and to Arrhenius Definitely decided not to come With this he had finally released himself from a dilemma which had been a burden to him for so long He did not want to deliver the lecture but at the same time was anxious to fulfil his obligations to the Academy In a subsequent letter to Arrhenius on October 10th he hoped that they would not be dissatisfied with him He pointed out that he had intended the whole time to fulfil his duties and hoped that he would not be reproached for withdrawing when it was made clear to him that there was no actual obligation

This correspondence obviously indicates that the idea of travelling to Stockholm and of delivering a public lecture gave Rontgen a constant feeling of uneasiness He clearly regarded the journey as long and difficult and it is possible also that unpleasant memories of the heavy seas on his journey to the prize distribution a year earlier in December contributed to this attitude There is no doubt however that the main reason was his manifest shyness of public appearances With obstinacy Rontgen put up a fight against the demands for a public life that was pouring upon him from all parts of the world He was obviously by nature a conscientious man who wished to safeguard his routine against unwelcome interruptions. He was happiest with the daily work at his own institute and when engaged in systematic lecturing Leave of absence during a university term went against his nature

Translation of letter from Röntgen to Arrhenius dated Munich 10 October 1902

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FROM THE DEPARTMENTS OF DIAGNOSTIC RADIOLOGY (DIRECTOR E MOSEKILDE) AND SURGERY L (DIRECTOR N BLIXENKRONE MOLLER) AND THE RADIUM CENTRE (DIRECTOR S KAAE) THE MUNICIPAL HOSPITAL, AARHUS DENMARK

LYMPHOGRAPHIC DEMONSTRATION OF CISTERNA CHYLI TRAUMA

Intralymphatic injection of patent blue violet during operation

by

H BRINCKER H INGSTRUP T S JENSEN and H SKJOLDBORG

Few reports on chylous effusion into the pleural or peritoneal cavity demonstrated by lymphangiography with oily contrast media have appeared since 1963 Such effusions may arise from lesions in the abdominal or thoracic lymphatics due to congenital traumatic or malignant conditions (CAMIEL et coll 1964 CHAVEZ & CONN 1966 CRAVEN et coll 1967 HEILMAN & COLLINS 1963 KINMONTH & TAYLOR 1964)

If chylous effusions do not yield to conservative management surgery may be indicated (CHAVEZ & CONN HARDY et coll 1962), although radiologically demonstrated *lymphatic fistulae* may be located only with difficulty at operation Operative demonstration of thoracic duct lesions has therefore sometimes been obtained by injecting a dye into the lower part of the oesophagus (COHN JR et coll 1958 HARDY et coll)

The present communication is a report on traumatic injury to the cisterna chyli with chylous ascites, in which the site of the lesion was demonstrated pre

Submitted for publication 1 October 1968

SUMMARY

The first Nobel Prize in Physics was awarded by the Swedish Academy of Sciences to Wilhelm Conrad Rontgen in 1901 for the discovery of the radiation that now bears his name Rontgen attended the prize presentation ceremony but he gave no Nobel lecture The reasons as indicated by two letters from Rontgen to Arrhenius a member of the committee are given

ZUSAMMENFASSUNG

Der erste Nobelpreis fur Physik wurde von der Schwedischen Akademie der Naturwissen schaften im Jahre 1901 Wilhelm Conrad Rontgen zuerteilt Rontgen war bei der Preis austeilungszeremonie anwesend aber die Nobel Vorlesung kam nicht zustande Die Ursachen werden mit zwei Briefen von Rontgen an Arrhenius ein Mitglied der Komitee beleuchtet

RÉSUMÉ

Le premier Prix Nobel de Physique fut attribué par l Academie Suedoise des Sciences a Wilhelm Conrad Rontgen en 1901 pour la decouverte du rayonnement qui porte maintenant son nom Rontgen assista a la remise du prix mais ne fit pas la conférence que l on attendait de lui Les raisons telles qu elles sont indiquees par deux lettres de Rontgen a Arrhenius membre du comite sont expliquees

SOURCES OF DOCUMENTATION

Letters from RONTGEN *to*

ARRHENIUS, dated November 16th 1901 April 17th and 26th October 6th and 10th 1902 The Swedish Royal Academy of Sciences Stockholm

SECRETARY OF THE SWEDISH ROYAL ACADEMY OF SCIENCES dated November 24th 1901 Deutsches Rontgenmuseum Remscheid Lennep West Deutschland

Letters to RONTGEN *from*

SECRETARY OF THE SWEDISH ROYAL ACADEMY OF SCIENCES dated November 17th and 27th 1901 October 14th 1902 Deutsches Rontgenmuseum Remscheid Lennep West Deutschland

ARRHENIUS dated November 21st 1901 April 22nd and October 2nd 1902 Deutsches Rontgenmuseum Remscheid Lennep West Deutschland

CHAIRMAN OF THE NOBEL COMMITTEE FOR PHYSICS dated October 6th 1902 Deutsches Rontgenmuseum Remscheid Lennep West Deutschland

FROM THE DEPARTMENTS OF DIAGNOSTIC RADIOLOGY (DIRECTOR F MOSEKILDE) AND SURGERY I (DIRECTOR N BLIXENKRONE MØLLER) AND THE RADIUM CENTRE (DIRECTOR S KAAE), THE MUNICIPAL HOSPITAL AARHUS DENMARK

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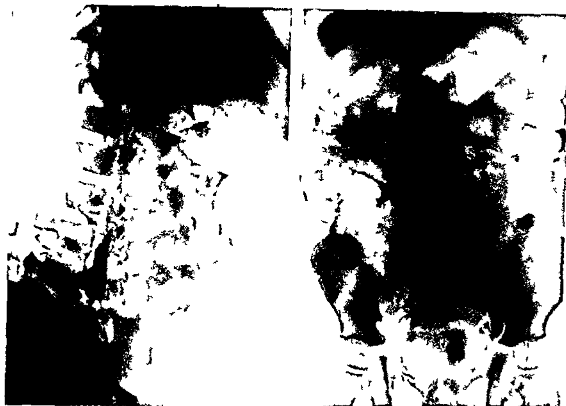
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Preoperative lymphangiography with leak of contrast medium at the level of L1 into the *peritoneal cavity* (*left*) and 3 hours later (right) peritoneal effusion of the medium

operatively by lymphangiography and during the operation by intralymphatic injection of patent blue violet into the foot This method of disclosing a lesion in the lymphatic system during operation does not appear to have been described previously

Case report

A boy aged 2 years and 9 months previously in good health was admitted because of increasing circumference of the abdomen for 3 to 4 days diffuse abdominal pain and anorexia One week before admission he had tripped over a bicycle and hurt his abdomen The abdomen was distended with ascitic fluid and had a marked venous pattern Immediate laparocentesis released 500 ml of chylous fluid and further laparocentesis 2 weeks later yielded 1 500 ml more fluid

Lower extremity lymphangiography produced satisfactory inflow only on the left side where 6 5 ml Lipiodol Ultrafluid 38 % were injected This gave satisfactory filling of apparently normal lymphatics and lymph nodes on the left side as far as the junction of L1—L2 where oozing of contrast medium into the peritoneal cavity (see accompanying figure) was observed There were no signs of filling of the thoracic duct supraclavicular lymph nodes or pulmonary parenchyma neither immediately after the injection of the con

trast medium nor 24 hours later The lymphangiographic findin s thus suggested injury to the abdominal lymphatics at the level of the cisterna chyli

Laparotomy was performed 17 days after admission Before the operation a lymphatic on the ri ht foot was exposed and through this vessel patent blue violet 0 25 % in physiologic saline was inje ted manually several times in the course of the operation About 25 ml in all of this solution v as used

Opening of the peritoneum disclosed about *1 500 ml of a slightly blueish chylous ascitic* fluid Oozing of patent blue violet was then observed to take place beneath the mesentery of the small intestine in the left iliac fo sa Further exploration of this area revealed no signs of ruptured lymphatics but the dye made it evident that the lymph passed retroperitoneally into the left iliac fossa from a traumatic le ion of the lower part of the cisterna *chyli The latter w s expo ed and ligated* above and below the site of perforation A perforated lymbatic on the left of the cisterna chyli and one at the level of the first intestinal branch of the uperior mesenteric artery were also ligated Before the ligatures v ere applied an injection of patent blue violet produced colour through the defects into the abdomen 10 to 20 econds later After the sites had been ligated continued injection of the dye was follo ed by rupture of a small lymphatic ve sel this was ligated No further dye was injected the abdomen v as closed and retroperitoneal suction drainage applied

No signs of further effusion v ere evident during the fir t five days alter operation and *there was only minimal discharge from the drain which v as therefore removed However* chylous fluid nov started appearing again and neces itated laparocenteses seven ten and eleven days after the operation a total of 5 700 ml of fluid being removed

A further operation the day after the last laparocentesis disclosed a lymphatic fistula to the left of the inferior mesenteric artery in close proximity to the lymphatic fistulae dem onstrated at the *primary operation* Due to the ligature it was possible *this time to locate* the le ion without using any contrast medium or dye The fistula was tied The patient was di charged in perfect health six v eeks after admission Two months later he was still fit

Discussion

The present case like previously reported cases substantiates the value of lymphangiography with oily contrast media in demonstrating lesions of the intra abdominal lymphatics

The intralymphatic injection of patent blue violet was of decisive importance *in the present case* in the exact location of the cisterna chyli and of the ruptured lymphatics during the primary operation Moreover injection of the dye after ligation confirmed *that all the defects had been closed* By subcutaneous injection of the dye into the dorsum of the foot CULLHED (1966) failed to obtain any distinct blue staining of the iliac and lumbar lymphatics Without direct intra lymphatic injection of the solution only a diffuse greenish blue staining of tissues is obtained which does not make it any easier to identify the lymphatics

The fact that during the primary operation a lymph trunk was observed to have ruptured during the injection of the dye indicates the possibility that similar le ions may occur during lymphangiography and lead to chylous effusions This is likely to occur particularly in cases of lymphatic abnormalities associated with

increased hydrodynamic pressure However, no case of this nature seems to have been reported, unless the one of CAMIEL et coll (1964) may have been such a one

SUMMARY

Traumatic injury to the cisterna chyli caused chylous ascites in a boy aged 2 years and 9 months The site of the lesion was demonstrated pre operatively by lymphangiography and during the operation by direct intralymphatic injection of dye into the foot

ZUSAMMENFASSUNG

Chylascites wurde durch traumatische Verletzung der Cisterna chyli in einem zwei Jahre und neun Monate alten Jungen verursacht Die Läsion wurde preoperativ bei Lymphangiographie lokalisiert und während der Operation mittels direkter intralymphatischer Einspritzung von Farbstoff in den Fuss dargestellt

RESUMÉ

Une lesion traumatique de la citerne de Pecquet chez un garçon âge de 2 ans et 9 mois a donne lieu a une ascite chyleuse Le siege de la lesion a ete mis en evidence avant l operation par lymphographie et au cours de l operation par une injection intralymphatique directe de colorant au niveau du pied

REFERENCES

CAMIEL M R BENNINGHOFF D L and HERMAN P G Chylous ascites with lymphographic demonstration of lymph leakage into the peritoneal cavity Gastroenterology 47 (1964) 188

CHAVEZ C M and CONN J H Thoracic duct laceration Closure under conservative management based on lymphangiography evaluation J thorac cardiovasc Surg 51 (1966) 724

COHN JR I, LEON W and STRUG L H Vital staining of the thoracic duct Ann Surg 148 (1958) 867

CRAVEN C F GOLDMAN A S LARSON D I et coll Congenital chylous ascites Lymphangiographic demonstration of obstruction of the cisterna chyli and chylous reflux into the peritoneal space and small intestine J Pediat 70 (1967) 340

CULLHED S Contribution during I International Symposium on Lymphology Zurich 1966

HARDY J D WALKER JR G R and DECUZMAN V C Thoracic duct fistula in infant Blue dye localization and operative closure J Amer med Ass 182 (1962) 187

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KINMONTH J B and TAYLOR G W Chylous reflux Brit med J 1 (1964) 529

FROM THE DEPARTMENTS OF RADIOLOGY (DIRECTOR PROF T ADACHI) AND SURGERY (DIRECTOR PROF K KAWASHIMA) THE TOKYO MEDICAL AND DENTAL UNIVERSITY SCHOOL OF MEDICINE TOKYO, JAPAN

SIALOGRAPHIC STUDY OF DISEASES OF THE MAJOR SALIVARY GLANDS

by

SOJI SUZUKI and KENKICHI KAWASHIMA

The roentgenographic demonstration of the salivary gland in the living human subject was first performed by ARCELIN in 1913 who successfully revealed a sialolith in Wharton s duct with a bismuth suspension BARSONY (1925) diagnosed idiopathic dilatation of Stensen s duct in a 70 year old man with a potassium iodide solution the patient apparently experienced severe pain and developed transitory facial palsy following the injection JACOBOVICI et coll (1926) suggested the term sialographie which has since been widely used to designate the roentgenographic demonstration of the salivary glands and their ducts CARLSTEN (1926) was the first to use Lipiodol for sialography and demonstrated dilatation of Stensen s duct with this method

In spite of increasing experiences since its inception by ARCELIN sialography has as stated by HOLT, always been "a neglected stepchild of roentgen diagnosis There seem to be two main explanations for the unpopularity of the procedure (1) underestimation of its importance in the diagnosis and differential diagnosis of pathologic processes not only in but also adjacent to the major salivary glands and (2) the fact that it may cause pain and functional disturbances as well as

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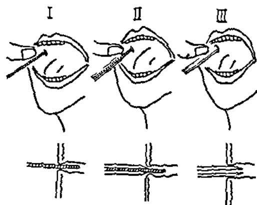


Fig 1 Illustration of the sialographic technique



Fig 2 a) Conventional film Huge stone in the submandibular gland b) The ductules are dilated

changes, associated with the injection of contrast media, especially oily media, under high pressure

In the early days a blunt needle or cannula was attached to a syringe and the medium injected into the salivary duct (ref 1, 5 10 16) The orifice of the salivary duct was usually enlarged with lachrymal dilators or graded filiform whalebone bougies prior to the insertion of the needle or cannula, if necessary, the orifice was even slit GULLMO & BOOK HEDERSTROM made a special needle that prevented the medium from leaking into the oral cavity from between the needle and the duct wall They also recommended the use of polythene tubing filled with the water soluble medium and connected to the needle The plastic tube ensured that the medium was introduced into the salivary gland under fairly constant hydrostatic pressure PARK & MASON (1966) described almost the



Fig 3 Sialolith (indicated by arrow)



Fig 4 Stone in Wharton s duct (arrow)

ame technique and stated that hydrostatic sialography was superior to the hand injection method

RUBIN & BLATT (1957) introduced a sialographic technique called secretory sialography They inserted a polythene tube with a metal stylet deep into the salivary gland, the orifice of which had been previously enlarged with lachrymal dilators. Upon the completion of the injection of Pantopaque (ethyliodophenyl undecylate), the open end of the tube was plugged with a wooden stopper and roentgenograms were obtained The tube was then withdrawn and the salivary gland stimulated by the chewing of a slice of lemon a further roentgenogram was produced after the mouth had been rinsed

Since CARLSTEN first used Lipiodol in sialography iodinated oils or similar media, such as Lipiodol Ultrafluid or Pantopaque have been considered as contrast media of choice in sialography by various workers (10 12 13 16 17) The oily media may however because of their viscid nature impair the function or even damage the tissues of the salivary gland (7)

Water soluble iodinated organic compounds such as Hypaque Urografin Triosil have been tried in sialography by a few workers Urografin 76 % the iodine concentration of which is 37 % should produce as excellent radiographic contrast as Lipiodol unless the former should be diluted by excessive saliva or leak into the oral cavity through the space between the wall of the duct and the needle

The present authors first applied the catheter replacement technique (SELDINGER) in sialography in 1959 A polythene tube inserted into Wharton s duct was tightly held in place there was no evidence of leakage of the contrast medium into the oral cavity Since then this method has been used in a series of 160 sialographies Approximately two thirds of the material were parotid

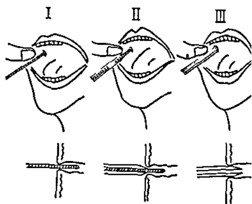


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Fig 7 Recurrent parotitis in a 55 year-old woman Cyst like changes in the parenchyma

and tube together The metal guide is withdrawn when the tube has been inserted deep into the salivary duct

A needle with stopcock is attached to the polythene tube and the medium slowly *injected under constant low pressure any air in the instruments must be* completely removed prior to the injection The amount of medium should be limited to 2 5 ml in parotid and 2 0 ml in submandibular sialography On completion of the injection the stopcock is closed and the syringe is disconnected

Material and Results

The pathologic processes in the present series are divided into four groups as follows (1) sialolithiasis (2) sialoadenitides or sialoadenoses (3) salivary gland tumors and (4) tumors to be differentiated from salivary gland tumors (para sialomas)

1 *Sialolithiasis*

A salivary stone is not uncommon in adults and is characterized by painful swelling of the salivary gland aggravated by the ingestion of food A review of the literature by RAUCH disclosed that the incidence of calculus formation was highest in the submandibular gland or its duct (Wharton s duct) i e 83 % The incidence in the parotid gland including Stensen s duct was 10 % and in the sublingual glands 7 % it was higher in males than in females and uncommon *in children of both sexes Multiple stones occurred in* 25 % of all the patients reviewed by RAUCH

Salivary calculi may be minute or very large or vary anywhere between these extremes (Figs 2 3 4 and 5) They were however in the present material mostly less than a cubic centimeter in volume and ranged from 0 1 to 1 0 gram in weight

Sixteen patients of the present series had had submandibular sialolithiasis nine



Fig 5 Air bubble in middle part and stone in posterior part of Wharton s duct



Fig 6 Sequelae of purulent parotitis

sialographies, the remaining third being submandibular sialographies No attempt has been made to perform sialography of the sublingual glands

Though none of the parotid sialographies was unsuccessful, submandibular sialography failed in eleven patients, because of their difficulty in opening the mouth, or inability of the operator to find the orifice of the Wharton s duct

Urografin 76 % and Lipidol Ultrafluid have been employed in most of the sialographies, though Lipiodol Pantopaque and Endografin have proved just as excellent as the first mentioned two contrast media

Technique Our technique is schematically illustrated in Fig 1 The metal guide is 0 7 mm in diameter and 15 cm in length, its tip being blunted so as not to injure the mucous membrane of the salivary duct The polythene tube, which is carefully disinfected, is tapered at its tip The patient is placed in a chair and with face upwards Neither general nor local anesthesia is required, though pre medication with 35 mg or 70 mg meperidine may be indicated in nervous subjects

The orifice of Stensen s duct lies opposite the upper second molar tooth and the opening of Wharton s duct at the sublingual caruncle The insertion of the metal guide is not always easy especially in submandibular sialography The tip of the guide can be advanced in Stensen s duct to the point where the duct is circumvented by the anterior border of the masseter muscle and in Wharton s duct, unless it is obstructed, to its posterior end The polythene tube is then threaded on the metal guide and slid into the salivary duct Some resistance may be encountered when the tip of the tube passes through the sphincter orifice of the duct This is however easily overcome by a slight thrust upon the guide



Fig 10 Segmented dilatations in a 10-year-old girl



Fig 11 Rounded filling-defect caused by pleomorphic adenoma.

2 *Sialoadenitides and sialoadenoses*

Acute sialoadenitis Sialography is undoubtedly contra indicated in acute sialoadenitis but the authors have not infrequently been obliged to perform sialography in a patient with an acutely inflamed salivary gland in order to rule out sialolithiasis In none of the patients however did an exacerbation of signs and symptoms follow the sialography Some patients even experienced some improvement The changes in acute sialoadenitis if present are not conspicuous or are only slight Acute purulent sialoadenitis if marked may however produce detrimental sequelae to the duct system of the gland

Fig 6 is a parotid sialogram of a 35 year-old man who suddenly developed painful swelling of the left parotid region in association with purulent discharge from the orifice of Stensen s duct 3 weeks prior to the sialographic examination The acute inflammatory process and pus discharge promptly subsided on penicillin when sialography was performed to rule out a sialolith in the Stensen s duct The sialogram revealed ectatic changes in the parotid gland and irregularity of the wall and lumen of Stensen s duct but no sialolithiasis

Chronic recurrent sialoadenitis Recurrent sialoadenitis is not uncommon in patients with poor mouth care Though the etiologic features of chronic recurrent parotitis in otherwise healthy subjects is still not fully clarified it predominantly occurs in post menopausal women and in infants or children of both sexes (2) Micro-organisms such as pneumococci streptococci and staphylococci are frequently isolated from saliva from the affected gland (12) In the present series three of the patients were post menopausal women and three were children



Fig 8 Sjogren s syndrome in a 60 year old woman



Fig 9 Sjogren s syndrome in a 47 year old woman

being males and seven females the ages ranging from 21 to 63 years of age (average 44 2 years) Five had multiple stones Among a total of 24 verified calculi twelve were located in the extraglandular portion of Wharton s duct and ten calculi within the submandibular gland, including the intraglandular portion of Wharton s duct The remaining two stones lay in the duct of the accessory gland The right submandibular gland or its duct was affected in nine, and the left in seven patients

A homogeneous accumulation of contrast medium in a submandibular gland (Figs 3 and 4) is an indication of marked destruction of the parenchyma of the gland secondary to the incarceration of the stone in Wharton s duct Simple lithotomy is, as a rule insufficient in these cases, and complete removal of the submandibular gland including Wharton s duct may promise better result Recurrence of sialolithiasis is not infrequent following the former procedure

A filling defect caused by air can usually be easily distinguished from one produced by stone, as exemplified in Fig 5 The salivary stone is mainly com posed of calcium carbonate or calcium phosphate and is not infrequently strat ified Because of the high concentration of lime, it may be picked up in the conventional roentgenogram unless overlapped by bony structures A sialolith in the submandibular gland or Wharton s duct was clearly identified in the occlusal dental film in all the nine patients of the present material who were examined by the intra oral method Since water soluble contrast media tend more accurately to delineate the contour of the stone than oily media, the present authors prefer Urografin 76 % to the latter whenever sialolithiasis is likely



Fig 13 Large pleomorphic adenoma displacing the parotid gland upwards



Fig 14 Large dermoid in the submandibular region displacing the submandibular gland

Miscellaneous Bilateral swelling of the parotid glands is not infrequently encountered in sarcoidosis and two such patients were represented in the present series Both these patients had been treated with steroids and the sialographies proved to be normal

Four patients of the present material had Mikulicz's syndrome (see ref 11 and 19) Three of them had bilateral swelling of the parotid glands with eosinophilic granuloma of the lymph nodes at biopsy The sialograms revealed slight irregularity of Stensen's duct and the intraglandular ductules but fairly normal appearance of the parenchyma The condition of the fourth patient was identical with that reported by MIKULICZ in 1888 i e symmetric swellings of the parotid and lacrimal glands of unknown etiology The contrast medium outlined a normal duct system throughout the enlarged parotid glands

Marked dilatation of the salivary ducts unassociated with stone or stenosis of the ducts is rare Fig 10 is a left parotid sialogram of a 10-year-old girl who had slight swelling of the parotid region without purulent discharge from Stensen's duct The duct was segmentally dilated in a bead fashion but the intraglandular ductules and the gland parenchyma appeared almost normal Though Stensen's duct may be segmentally dilated in chronic recurrent parotitis of the adult type such dilatation was less marked and more irregular than in two patients with segmental dilatations of Stensen's duct of unknown etiology

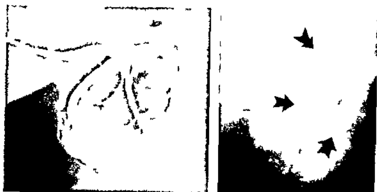


Fig 12 Lateral (left) and p a (right) views of pleomorphic adenoma

The duct system was only distended in two of the adults but in the third cystic pools of medium indicated gross destructive changes in the parenchyma of the parotid gland (Fig 7)

Recurrent parotitis in the infantile group usually responds well to antibiotics, especially penicillin, and recurrence may become less frequent and severe until, as the patient grows older, complete remission occurs The sialographic changes in the infantile form were much less severe than those in the adult, and there was only slight irregularity in Stensen s and the intraglandular ductules in all three cases

Sjogren's syndrome Keratoconjunctivitis sicca associated with mucosal xerosis of the digestive as well as the respiratory tracts, rheumatoid arthritis and swelling of the parotid glands is called Sjogren s syndrome, the etiology of which has not been thoroughly elucidated There were seven patients with the syndrome in the present series, they were all female, aged 38 to 60 (average 50 4 years)

Swelling of the parotid gland was evident in all but one patient and was bilateral in type Sialography may reveal small cyst like cavities scattered throughout the parotid gland, as shown in Figs 8 and 9 Recurrent episodes of ascending infection of the parotid gland may occur in patients with Sjogren s syndrome, and characteristic roentgen appearances may be produced by this condition as well as by recurrent parotitis It would appear, however that the cystic cavities in Sjogren s syndrome are more uniform in shape and size than those in chronic recurrent parotitis in the adult

The present material included five patients with keratoconjunctivitis sicca simplex or symptomatica with normal sialograms



Fig 16 Cyst within a Warthin's tumor

rounded by displaced ductules and parenchyma (Figs 11 and 12) As the mass grows larger the salivary gland as a whole may be displaced (Fig 13) The sialographic diagnosis of pleomorphic adenoma may be made with ease if the tumor is small and situated deep in the salivary gland but with some difficulty if it displaces the salivary gland as a whole a large tumor adjacent to the salivary gland may frequently alter the position of the entire salivary gland (Fig 14)

Malignant tumors of the salivary glands are less common than pleomorphic adenomas There are only three representative patients in the present series. Most of the malignant tumors occur in the sixth or later decades and are clinically characterized by rapid growth poorly circumscribed margin of the mass due to its infiltrative nature frequent association with neuralgic pain or if a parotid tumor facial palsy and lymphatic or distant metastases

The most important of the sialographic findings in malignancy is the leakage of medium from the eroded ductules into the tumor or the gland parenchyma (Fig 15) Such a leakage was observed in all the three patients with carcinoma but on the other hand in none of the fifteen patients of the present series with pleomorphic adenoma

Fig 16 is a right parotid sialogram of a 70-year old man with a large cystic tumor of the right infra auricular region Sialography revealed a cystic cavity which was found to contain pus The growth was histologically a papillary cystoadenoma lymphomatosum (Warthin's tumor) and apparently belonged to the benign subgroup of sialomas Leakage of medium into the cystic cavity was secondary to inflammatory destruction of the duct system rather than to infiltration by malignant cells

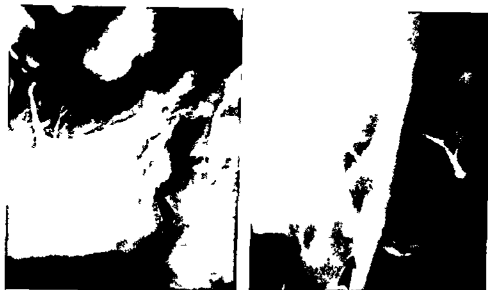


Fig 15 Lateral (left) and a p (right) views of adenocarcinoma of the parotid gland leakage of contrast medium (arrows)

Salivary gland tumors

Tumors of the salivary glands are classified as parenchymatous (sialomas) and interstitial (syn sialomas) in RAUCH s monograph The former (95 4 % of 2 059 cases of the salivary gland tumors collected from the materials of KIRKLIN, REDON and FOOTE) are further sub divided into three subgroups, i e benign, semi malignant and malignant The interstitial (4 6 %) are vascular tumors, lymphomas and other neoplasms interstitial in origin Pleomorphic adenomas (mixed tumors), belonging to the semi malignant subgroup comprise about three quarters of all sialomas and thus have the highest incidence

Fifteen patients (eight females and seven males) had pleomorphic adenomas in the present material, all on one side The average age of these patients was 47 1 (ranging from 20 to 74 years of age) when sialography was performed Nine tumors arose from the parotid, six from the submandibular and none from the sublingual gland

Of a large series of pleomorphic adenomas collected from the literature by RAUCH 84 % were parotid, 8 % submandibular and 0 5 % sublingual in origin They also arose from sites other than the major salivary glands in 7 5 % of the material

A pleomorphic adenoma is characterized sialographically by a well circum scribed filling defect or indentation in the salivary gland without leakage of medium into the parenchyma or the neoplasm The defect, if still small, is sur

SUMMARY

It is stated on the basis of 160 sialographies that the procedure is indispensable in the diagnosis of sialolithiasis, chronic sialoadenitis and various sialoadenopathies. Sialography may also play an important role in the differential diagnosis of sialomas and parasialomas.

ZUSAMMENFASSUNG

Es wird hervorgehoben, anlässlich 160 Untersuchungen mit Sialographie, dass die Methode für die Diagnose der Speichelsteine, chronischer Entzündungen und anderer Erkrankungen der Speicheldrüsen unentbehrlich ist. Die Methode hat sich auch für die Differentialdiagnose von Speicheldrüsentumoren und Parasialomen wertvoll erwiesen.

RÉSUMÉ

Une série de 160 sialographies montre que cette technique est indispensable pour établir le diagnostic de lithiases salivaires, d'adénites salivaires chroniques et de diverses affections des glandes salivaires. Les auteurs décrivent la technique. La sialographie peut aussi jouer un rôle important dans le diagnostic positif et dans le diagnostic différentiel des sialomes et des parasialomes.

REFERENCES

1 Barsony T. Idiopathische Stenongang-Dilatation. Klin. Wschr. 11 (1933) 2000.
2 Bataille R. Les parotidites récidivantes. Presse méd. 65 (1957) 1952.
3 Blatt I. M. and Maxwell J. H. Secretory sialography. Trans. Amer. Acad. Ophthal. Otolaryng. 61 (1957) 492.
4 Boette C. und Wuttke K. H. Sialographische Darstellung von Parotiserkrankungen unter besonderer Berücksichtigung eines Boeckschen Sarcoids. Z. Laryngol. Rhinol. Otol. 37 (1958) 302.
5 Cardell B. S. and Gurling K. J. Observations on the pathology of Sjögren's syndrome. J. Path. Bact. (London) 68 (1954) 137.
6 Carlsten D. B. Lipiodolinjektion in den Ausführungsgang der Speicheldrüsen. Acta radiol. 6 (1926) 221.
7 Gullmo A. and Book Hederström G. A method of sialography. Acta radiol. 49 (1958) 17.
8 Holt J. F. Sialography (editorial). Radiology 68 (1957) 584.
9 Jacobovici, Popolitza et Albu. La Sialographie. Presse méd. 34 (1926) 1188.
10 Kimm H. T., Spies J. W. and Wolfe J. J. Sialography with particular reference to neoplastic diseases. Amer. J. Roentgenol. 34 (1935) 289.
11 Morgan W. S. and Castleman B. A clinicopathologic study of Mikulicz's disease. Amer. J. Path. 29 (1953) 471.
12 Ollerenshaw R. G. W. and Rose S. S. Radiological diagnosis of salivary gland disease. Brit. J. Radiol. 24 (1951) 538.
13 Osmer J. C. and Pleasants J. E. Distention sialography. Radiology 87 (1966) 116.



Fig 17 Parotid sialogram in 10 year old girl with an egg sized tumor in the right infra auricular region Large indentation in the lower portion of the gland which is displaced upwards (The diagnosis of a para sialoma was based upon the essentially normal volume of the gland the tumor was enucleated and proved to be a reticulo sarcoma arising from a lymph node)

Tumors adjacent to the salivary glands (para sialomas)

Palpation of a swelling in the infra auricular or submandibular region even by a skilled hand, may not uncommonly disclose insufficient information as to whether it arises from the salivary gland or outside it Sialography must then play an important role in the differential diagnosis provided the mass is marked with a piece of flexible wire (Figs 12 and 17)

Most of the soft tumors such as lymphoma, lymphangioma or hemangioma produce little distortion or deformity of the salivary gland ever though they seem to encroach upon it Hard tumors on the other hand, may produce an indentation in the gland or even displace it as a whole

Unlike the pleomorphic adenoma and other sialomas, para sialomas little affect the total volume of the parenchyma of the gland, even though they may distort or displace it to a marked degree This phenomenon is the most important of the sialographic findings upon which the differential diagnosis between sialoma and para sialoma is based (Fig 17)

Acknowledgement

The authors take this opportunity of expressing their thanks to K Mitsunaga of the Department of Internal Medicine for the establishment of the diagnosis of Sjogren's syndrome in all the patients of the present series

FROM ROENTGEN DEPARTMENT I (DIRECTOR PROF O BARTLEY) SAHLGRENSKA SJUKHUSET, GOTHENBURG SWEDEN

ROENTGENOLOGIC DETERMINATION OF CALCIUM CONCENTRATION OF SKELETAL BONE WITH DOUBLE BEAM APPARATUS

by

K ASTRAND N E AHLBERG O BARTLEY and N CHIDEKEL

Various roentgenologic methods of estimating the calcium content of the skeleton have been described since the end of the nineteenth century the simplest and most common consisting of its direct estimation from roentgen films This method is subjective and inexact and according to the literature a 30 % to 50 % reduction in the content is required before clear cut changes can be observed (BABAIANTZ 1947 1948 ARDRAN 1951) For some time attempts have been made to achieve a more objective estimation of the calcium content BARNETT & NORDIN (1960 1961) calculated the ratio of the thickness of the cortex and the diameter of the bone both measurements being obtained directly from roentgenograms Control cases were compared with a group that clinically had osteoporosis The investigation was carried out on different parts of the skeleton i e the femora and the metacarpal bones the concavities of the lumbar vertebrae were also measured Significant changes could be demonstrated in more than half the number of cases in the osteoporotic material

A number of methods have been described in which density differences be

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14 PARK W M and MASON D K Hydrostatic sialography Radiology 86 (1966) 116
15 PATEY D H and THACKRAY A C Chronic sialectatic parotitis in the light of pathological studies on parotidectomy material Brit J Surg 43 (1955) 43
16 PAYNE R T Sialography Brit J Radiol 5 (1932) 492
17 PUTNEY F J and SHAPIRO M J Sialography Arch Otolaryngol 51 (1950) 526
18 RAUCH S Die Speicheldrusen des Menschen G Thieme Verlag Stuttgart 1959
19 RUBIN P and HOLT J I Secretory sialography in diseases of the major salivary glands Amer J Roentgenol 77 (1957) 575
20 — and BESSE B L The sialographic differentiation of Mikulicz s disease and Mikulicz s syndrome Radiology 68 (1957) 477
21 SJOGREN H Zur Kenntnis der Keratoconjunctivitis sicca (Keratitis filiformis bei Hypofunktion der Tranendrusen) Acta ophthal (1933) Suppl No 2



Fig 2 Measurement apparatus

composed of hydroxyapatite and the other contained water The wedges were servo-controlled and a digital computer solved an equation system obtained by the application of Lambert s law The detector was a scintillation counter with a thallium activated sodium iodide crystal Two roentgen beams from a single source were employed and the measurements were made on the metacarpal bone of the thumb

Methods with gamma radiation have also been described GERSHON COHEN et coll (1958) employed ^{192}Ir as the source of radiation and a scintillation counter as detector These authors described the results of measurements of lumbar vertebrae in three cases The error of method was given as ± 10 % CAMERON et coll (1963 1964) used ^{125}I or ^{241}Am as a monochromatic low energy source with a scintillation detector system and scanned the human radius with a 3 mm collimated beam at 1 mm intervals They stated that the experimental error was ± 8 %

For various reasons the demands imposed on methods for estimating the skeleton have recently become greater Osteoporosis grows more common with increasing life span Moreover even younger patients may be afflicted with decalcification by the widespread use of hormone therapy Since the earlier methods either carried large errors or were too complicated for routine purposes it was deemed worthwhile to design a new simpler apparatus for determination of the calcium content of skeletal bone One of us (K A) is primarily responsible for the theory and for construction of the apparatus

Fig 1 Schematic presentation of the measurement apparatus and circuit diagram of the bridge

tween roentgen films of the skeleton and a reference material were compared The first to use this technique was PRICE (1901) Much later, HEUCK & SCHMIDT (1960) analyzed the sources of error of these methods The film density alone may, according to them, be influenced by as many as seventeen factors These authors investigated chemically the calcium content of an anatomical material and compared the values obtained with densitometric measurements from films, they found that the error of method amounted to ± 10 % when the investigation was carried out over the proximal end of a femur The error was somewhat greater in measurements over a calcaneus VIRTAMA (1957) instead of making densitometric measurements determined the amount of silver dissolved from pieces cut from the skeleton part (metacarpal bone) of the roentgenogram

VOSE (1959) measured the absorption in the distal end of the femur with the aid of common polychromatic roentgen rays and an ionization chamber This investigator compared the absorption values with a reference consisting of a mixture of water and bone ash The error of method was reported to amount to ± 3 4 % MAYER et coll (1960) made use of a scintillation counter with a sodium iodide crystal in place of an ionization chamber They performed investigations on dried femur material and stated that the results were comparable to those obtained with the densitometric technique

Some investigators have used monochromatic roentgen rays FROMMHOLD & SCHOKNECHT (1960) employed a counter tube working in a proportionality region, the investigations being carried out on the fingers, the absorption was registered graphically JACOBSON (1963) described a theoretically attractive method for estimating the calcium content He used monochromatic roentgen rays of different wave lengths and two wedges as references One wedge was

Table 1

Triplicate measurements of roentgen absorbencies in four pieces of compacta of different thicknesses — Measurements carried out on each piece alone and on pieces in various combinations

Compacta		Absorbencies in mm reference wedge		
Piece	Thickness mm			
d	3 46	3 29	3 28	3 22
a	3 51	3 49	3 42	3 47
b	5 01	4 99	5 01	5 02
c	5 84	5 28	5 72	5 75
+b	8 52	8 40	8 34	8 33
a + c	8 35	9 18	9 14	9 13
b + c	10 85	10 51	10 45	10 43
a + b + d	11 58	11 24	11 37	11 52
b + c + d	14 31	13 63	13 45	13 42

with highly sensitive intensifying screens (Cawo extrema) taped to the photomultipliers The photo-multipliers are fed by stabilized direct voltage (1 010 V) and are connected to a simple amplifying bridge supplied by a stabilized voltage of 275 V The bridge (circuit diagram in Fig 1) contains a double triode (RCA 5751) with variable grid resistors permitting balancing of the amplified current from the photo multipliers

A µA meter (range −5 to +5 µA) is connected in series with resistors between the anodes of the triode a variation in the resistors will alter the sensitivity of the apparatus The beam passing through the test object is adjusted automatically to a predetermined level by means of a simple servomechanism which varies the anode current of the roentgen tube Control of this adjustment can be made with the bridge by disconnecting the reference side and comparing the voltage on the test object side with a standard voltage

Measurement of roentgen absorption

An anode voltage of about 65 kV is controlled with the extra voltmeter and kept constant Before each series of measurements the bridge is set at zero using an aluminium plate on the test object side and the aluminium reference wedge both positioned so that the same thickness breaks the two beams Thereafter the test object is substituted for the aluminium plate and the wedge adjusted so that the zero point on the µA meter is regained The reading on the indicator dial

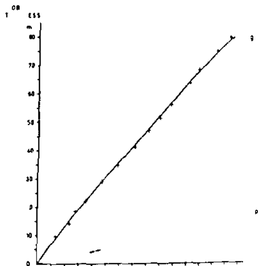


Fig 3 Function of the thickness in mm of plexiglas $f_m(x)$ or bovine compacta $f_c(x)$ or aluminium plate $f_{Al}(x)$ and roentgen absorbency (mm aluminium reference wedge) The $f_m(x)$ curve is based on duplicate readings made at about 1 mm intervals between 5 mm and 80 mm thickness of plexiglas each cross is the mean of three readings with the minced meat physiologic saline mixture

Double-beam apparatus for roentgen absorption measurements

The investigations were carried out with an apparatus employing polychromatic roentgen radiation and two photo multipliers (RCA 931 A) as detectors The roentgen tube has a focus of 1 2 mm and is fed by a single phase full wave rectified roentgen generator (Schonander DIK 1 000) An extra voltmeter for reading the primary potential corresponding to the anode voltage at fluoroscopy was installed

Roentgen rays pass through two brass tubes, fastened at at an angle of 15 2° to a plate which in turn is held by the arch and column stand of a Lysholm skull table (Figs 1 and 2) Each tube is fitted with a circular brass diaphragm 6 mm in diameter, and an aluminium filter at the end nearest the measurement region To compensate for the heel effect the filters are of different thicknesses 2 mm in the upper tube and 3 mm in the lower

An aluminium wedge breaks the path of the upper beam and supplies the reference This has approximately the same roentgen absorption as compacta (see Fig 3) The thickness of the reference wedge where it breaks the beam is read on an indicator dial to an accuracy of 0 01 mm The test object is placed in the other beam Each beam passes then through a 10 cm long brass tube These tubes are fitted with rectangular slit diaphragms (1 2 mm × 6 mm × × 42 mm) at the ends near the reference wedge and the test object The diaphragms are replaceable, and permit variations in size and shape of the beam as required The short brass tubes (Fig 2) act simultaneously as holders for the two photo multipliers, the latter are enclosed in brass containers and are fitted

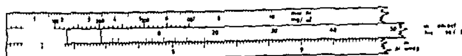


Fig 5 Calcium content slide rule set for an object thickness of 40 mm and a reading of 10 mm reference wedge The measured compacta contained about 203 mg Ca/cm²

in millimeter aluminium reference wedge were recorded The mean values corresponding to the different thicknesses are plotted in Fig 3

Theoretical The objective is to measure the thickness y mm of a substance c (compacta) surrounded by a less absorbing substance m (soft tissue) in a sample whose total thickness is d mm The sample is assumed to have a total absorption to a mm reference wedge Suitably calibrated curves must be obtained with the apparatus, allowing a measurement of y on the basis of the roentgen absorption a and the thickness d of the sample

Absorption curves were constructed for m and c separately and expressed in millimeter reference wedge i e $f_m(x)$ and $f_c(x)$ in Fig 4 The curve representing the difference $f_m(x)—f_c(x)$ is also inscribed

From curve $f_c(x)$ it can be seen that y mm of substance c corresponds to x_1 mm reference wedge and therefore has the same absorption as $f_m(x_1)$ mm of substance m Since the sample is composed of an additional $(d—y)$ mm of substance m it should have the same total absorption as $f_m(x_1) + (d—y)$ mm of this substance that is to say

$$f_m(a) = f_m(x_1) + d - y$$
$$f_m(a) - d = f_m(x_1) - y$$
$$\text{but } y = f_c(x_1)$$
$$f_m(a) - d = f_m(x_1) - f_c(x_1)$$

Thus one should arrive at y by subtracting the thickness of the sample d from $f_m(a)$ and at that level draw a line parallel to the x axis The point where this line crosses the difference curve $f_m(x) — f_c(x)$ is that x value on the x axis x_1 which corresponds to the sought y value

These calculations are not quite correct because the beam is polychromatic and therefore has a somewhat different spectrum passing through m or c or a mixture of these substances The error is small however (less than 0 1 mm Al) and has been corrected for empirically by construction of a new soft tissue absorption curve which lies immediately above the original $f_m(x)$

To avoid these relatively laborious calculations a special slide rule using the corrected soft tissue absorption curve was constructed (Fig 5) By setting the

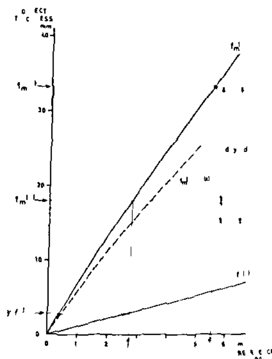


Fig 4 Representation of functions employed to calculate y mm compacta within an object d mm thick when the roentgen absorbency is a mm aluminium reference wedge

of the thickness in millimeters of the reference wedge corresponds to the roentgen absorption of the object

The balance of the bridge is controlled after every 3rd to 6th measurement Measurement values are considered acceptable only if the error is no greater than ± 0 3 μA in the sensitivity region employed The latter value corresponds to at the most ±0 08 mm aluminium The thickness of the test object is measured with vernier calipers

Preliminary experiments were carried out, in these, the roentgen absorbencies of compacta (bovine) and soft tissue (minced meat moistened with saline) were measured Four pieces of bovine compacta of 3 46 mm 3 51 mm, 5 01 mm and 5 84 mm thickness at the measurement site were employed The roentgen absorbencies of each piece alone and in various combinations were measured in triplicate (see Table 1) The thickness of compacta in millimeters was plotted against the mean of the readings in millimeter aluminium wedge (Fig 3)

The minced meat moistened with saline was packed firmly into two wedge shaped vessels made of thin plexiglas These wedges were juxtapositioned so that they formed parallel planes for measuring the thickness of the meat plus the container walls, and provided constant thickness throughout the area of the transmitted roentgen beam Triplicate measurements were made at each of 14 thicknesses between about 10 mm and 80 mm, and the roentgen absorbencies

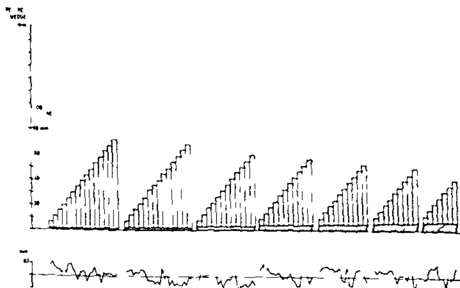


Fig 6 Results of seven series of model experiments performed with aluminium plates and different thickness of plexiglas (combined = object thickness) The points above each column indicate the duplicate readings in mm aluminium reference wedge Below each series the deviation of the calculated thickness from the actual thickness of the measured aluminium plate is plotted for each measurement

all of which varied in thickness The thickness of each sample was measured with a micrometer caliper to an accuracy of ± 0 01 mm

A total of 78 tests with aluminium plates and plexiglas were performed in duplicate The aluminium plates were 0 98 1 96 2 97 3 92 4 93, 5 94 and 6 93 mm thick while the plexiglas pieces differed in thickness by about 5 mm to a maximum which in combination with one of the aluminium plates gave a roentgen absorbency reading of about 14 mm aluminium wedge The seven series of tests are illustrated in Fig 6 The thickness of the aluminium plate in each series was then calculated from the reference wedge readings in millimeter and the measured thickness of the test object in millimeter (Al plate plus plexiglas) with the aid of the slide rule The deviations from the absolute thickness of the plate are plotted below each experimental series in Fig 6 The mean value for the deviations was 0 02 mm with a standard deviation of S = 0 046 With a 95 % confidence interval S 1 96 = 0 09 i e the error of a single reading was ± 0 11 mm If 6 mm Al is assumed equal to 100 % the corresponding error is 1 9 % At the mean value for 22 readings the error of method with 95 % probability is less than ± 0 7 %

Table 2

Results of the chemical analysis of four pieces of bovine compacta

Weight g	Volume ml	Spec gravity	Ash g	Ash %	Ca %
2.2343	1.0717	2.08	1.5639	69.9	26.9
3.7494	1.7764	2.11	2.6164	69.8	6.8
1.9704	0.9295	2.11	1.3753	69.8	25.6
2.9093	1.3773	2.11	2.0382	70.1	26.8
Mean		2.10		69.6	26.5

thickness of the test object (d mm) against its roentgen absorbency (a mm reference wedge), the thickness (y mm) of the substance c may be read opposite the zero point on the rule.

Two additional scales were also incorporated on the slide rule, one for aluminium graduated in millimeters and the other for compacta. The thickness of the latter has, however, been converted to mg Ca/cm² on the basis of the results of the chemical analysis of compacta (Table 2). The bovine compacta pieces contained $2.10 \times 0.265 \times 10^3 \times 10^{-1} = 55.6$ mg Ca per cm² per mm thickness, and the following relations were used to construct the scale:

Bovine compacta mm	Calcium mg/cm²
0.9	50
1.8	100
2.7	150
3.6	200
4.5	250
5.4	300
6.3	350
7.2	400

Model experiments. For standardization of the technique and testing the error of method, inert substances of uniform structure were required so that a circumstantial analysis of autopsy specimens which would be difficult to define could be avoided. Aluminium and plexiglas were tested and their roentgen absorbencies were compared with those of bovine compacta and minced meat, respectively. The results (Fig. 3) indicated the suitability of aluminium as a reference material and substitute for compacta, while plexiglas so closely approximated the minced meat in absorbency that the curves were almost identical. Model experiments were thus elaborated with samples of aluminium plates and plexiglas

Table 3

Results of six series of absorbency measurements in the right radius of a male aged 23 years

	Site in cm from wrist	Thickness mm	Absorbency in mm reference wedge	Calcium mg cm	Deviation from mean calcium values
Series 1	4		10 84	250	1 2
	5	40 7	11 12	269	—0 4
	6		11 57	300	1 7
	7		11 98	327	2 2
	8	40 6	12 73	353	[illegible]9
	9		12 44	358	0 8
	10		14 27	363	—0 3
	11	48 7	14 15	355	—4 3
	12		14 43	371	—1 1
	13	48 6	14 67	385	2 7
	14		14 57	379	4 1
				Mean	0 9
Series 2	4		10 98	260	5 3
	5	40 6	11 24	279	3 3
	6		11 61	304	3 1
	7		11 73	312	—2 5
	8	40 6	12 18	340	—0 9
	9		12 30	349	—1 7
	10		12 58	366	0 5
	11	40 7	12 0	375	1 1
	12		12 47	360	—4 0
	13		14 46	370	—1 3
	14	48 8	14 19	356	—2 2
				Mean	0 1
Series 3	4		10 64	236	—4 5
	5	40 7	11 15	270	0
	6		11 38	287	—2 7
	7		11 82	317	—0 9
	8	40 7	12 15	338	—1 5
	9		12 50	361	1 7
	10		12 44	358	—1 6
	11	40 7	12 76	379	2 2
	12		12 51	362	—3 5
	13		14 38	366	—2 4
	14	48 7	14 15	355	—2 5
				Mean	—1 4

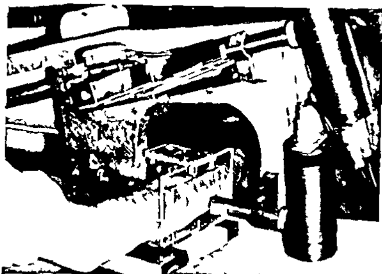


Fig 7 Right forearm of subject in place in the test object holder

Calcium content of human radius The distal half of the radius was chosen as the measurement region for the investigation in human subjects A special detachable measurement box was constructed (Fig 7) This was made of plexiglas and served two purposes, the first being to compress the soft tissue in the investigated region to an even thickness and the second to fix the arm so that the distal end of the ulna could be used as a reference point to establish the measurement sites along the radius To facilitate this, a scale was marked on the bottom plate of the box The object holder was fastened to a plate that could be raised and lowered to determine the region where minimum roentgen absorption through the radius was obtained In other respects the measurements and calculations were performed as described earlier

Measurements were made in two subjects, a man aged 23 (Table 3) and a woman aged 62 years (Table 4) Eleven sites along the radius at 1 cm intervals, 4 to 14 cm from the wrist, were employed Six series of measurements were performed in each The mean as well as the range of the six registrations at each site are given in Fig 8 Furthermore the calcium level of the older subject was calculated from the mean values obtained for the younger one as the standard at 100 % The average calcium level for the former was about 51 % of the standard

The standard deviations of the individual measurements from the mean values were, in percentages, S = 2 4 % for the values of the younger and S = 2 3 % for the older subject, thus S 1 96 = 4 7 % and 4 5 %, respectively This means

Table 4

Results of six series of absorbency measurements in the right radius of a female aged 62 years

	Site in cm from wrist	Thickness mm	Absorbency in mm reference wedge	Calcium mg/cm	Percentage of standard in Table 3	Deviation from mean calcium values
Series 1	4		8 81	118	47 8	1 0
	5	40 5	9 27	140	54 1	3 4
	6		9 57	167	56 1	2 4
	7		9 73	177	55 3	−1 6
	8	40 6	9 86	187	54 5	0 5
	9		9 95	193	54 4	−0 3
	10		11 26	179	49 2	−1 6
	11	48 8	11 09	165	44 5	−4 6
	12		11 34	183	48 8	0 7
	13		11 29	180	48 0	0 6
	14	48 8	11 07	165	45 4	−1 6
					Mean	−0 1
Series 2	4		8 58	102	41 3	−5 5
	5	40 7	9 12	135	50 0	−0 7
	6		9 32	149	50 5	−3 2
	7		9 84	184	57 5	0 6
	8	40 7	9 80	180	52 5	−1 5
	9		9 91	189	53 2	−1 5
	10		11 48	194	53 3	2 5
	11	48 7	11 52	198	53 4	4 3
	12		11 30	181	43 3	0 2
	13		11 40	188	50 1	2 7
	14	48 7	11 38	187	51 4	4 4
					Mean	0 2
Series 3	4		8 80	118	47 8	1 0
	5	40 5	9 17	141	52 2	1 5
	6		9 47	161	54 6	0 9
	7		9 78	182	56 9	0
	8	40 5	9 81	184	53 6	−0 4
	9		10 06	201	56 6	1 9
	10		11 45	190	52 2	1 4
	11	48 8	11 30	181	48 8	−0 3
	12		11 21	174	46 4	−1 7
	13		11 10	166	44 3	−3 1
	14	48 8	11 12	168	46 2	−0 8
					Mean	0 1

Table 3 *(cont)*

	Site in cm from wrist	Thickness mm	Absorbency in mm reference wedge	Calcium mg/cm²	Deviation % from mean calcium values
Series 4	4		10 75	245	—0 8
	5	40 6	11 01	263	—2 6
	6		11 41	290	—1 7
	7		11 82	319	—0 3
	8	40 6	12 11	337	—1 7
	9		12 32	350	—1 4
	10		12 55	366	0 5
	11	40 7	12 67	374	0 8
	12		12 98	391	4 3
	13		14 77	391	4 3
	14	48 6	14 64	385	5 8
				Mean	0 7
Series 5	4		10 67	239	—3 2
	5	40 5	11 11	270	0
	6		11 46	294	—0 3
	7		11 78	315	—1 6
	8	40 6	12 17	340	—0 8
	9		12 39	355	0
	10		12 62	370	1 6
	11	40 5	12 51	364	—1 9
	12		12 71	377	0 5
	13		14 30	365	—2 7
	14	48 5	14 07	351	—3 3
				Mean	—1 1
Series 6	4		10 86	253	2 4
	5	40 6	11 07	266	—1 5
	6		11 51	297	0 7
	7		11 98	329	2 8
	8	40 6	12 31	350	2 4
	9		12 37	354	—0 3
	10		12 47	361	—0 8
	11	40 6	12 70	376	1 3
	12		12 92	389	3 7
	13		14 40	372	—0 8
	14	48 5	14 14	356	—2 2
				Mean	0 7

Mean values of calcium at each measured site used as standard values

Site	4	5	6	7	8	9	10	11	12	13	14
Mean	247	270	295	320	343	355	364	371	375	375	364

Table 4

Results of six series of absorbency measurements in the right radius of a female aged 62 years

	Site in cm from wrist	Thickness mm	Absorbency in mm reference edge	Calcium mg cm	Percentage of standard in Table 3	Deviation from mean calcium values
Series 1	4		8 81	118	47 8	1 0
	5	40 5	9 27	146	54 1	3 4
	6		9 57	167	56 1	2 4
	7		9 73	177	55 3	− 1 6
	8	40 6	9 86	187	54 5	0 5
	9		9 95	193	54 4	−0 3
	10		11 26	179	49 2	−1 6
	11	48 8	11 09	165	44 5	−4 6
	12		11 34	183	48 8	0 7
	13		11 29	180	48 0	0 6
	14	48 8	11 07	165	45 4	−1 6
					Mean	−0 1
Series 2	4		8 58	102	41 3	−5 5
	5	40 7	9 12	135	50 0	−0 7
	6		9 32	149	50 5	−3 2
	7		9 84	184	57 5	0 6
	8	40 7	9 80	180	52 5	−1 5
	9		9 91	189	53 2	−1 5
	10		11 48	194	53 3	2 5
	11	48 7	11 52	198	53 4	4 3
	12		11 30	181	43 3	0 2
	13		11 40	188	50 1	2 7
	14	48 7	11 38	187	51 4	4 4
					Mean	0 2
Series 3	4		8 80	118	47 8	1 0
	5	40 5	9 17	141	52 2	1 5
	6		9 47	161	54 6	0 9
	7		9 8	182	56 9	0
	8	40 5	9 81	184	53 6	−0 4
	9		10 06	201	56 6	1 9
	10		11 45	190	52 2	1 4
	11	48 8	11 30	181	48 8	−0 3
	12		11 21	174	46 4	−1 7
	13		11 10	166	44 3	−3 1
	14	48 8	11 12	168	46 2	−0 8
					Mean	0 1

Table 4 *(cont)*

	Site in cm from wrist	Thickness mm	Absorbency in mm reference wedge	Calcium mg/cm²	Percentage of standard in Table 3	Deviation % from mean calcium values
Series 4	4		8 86	121	49 0	[illegible] 2
	5	40 6	9 10	134	49 6	—1 1
	6		9 63	170	57 6	3 9
	7		9 79	180	56 3	—0 6
	8	40 7	9 87	185	53 9	—0 1
	9		10 10	200	56 3	1 6
	10		11 30	181	39 7	—1 1
	11	48 8	11 35	184	46 6	0 5
	12		11 49	193	51 5	3 4
	13		11 27	178	47 5	0 1
	14	48 8	11 14	170	46 7	—0 3
					Mean	0 8
Series 5	4		8 79	115	46 6	—0 2
	5	40 6	9 17	139	51 5	0 8
	6		9 60	167	56 6	2 9
	7		9 98	190	59 4	2 [illegible]
	8	40 8	9 87	184	53 6	—0 4
	9		9 97	190	53 2	—1 [illegible]
	10		11 49	195	53 6	2 8
	11	48 6	11 34	185	49 9	—0 8
	12		11 23	178	47 5	—0 6
	13		11 23	178	47 5	0 1
	14	48 6	11 17	173	47 5	0 [illegible]
					Mean	0 7
Series 6	4		8 83	119	48 2	1 4
	5	40 7	9 00	126	46 7	—4 0
	6		9 15	136	46 1	—7 6
	7		9 78	179	5[illegible] 9	—1 0
	8	40 7	9 95	191	55 7	1 7
	9		9 96	191	53 8	—0 9
	10		11 11	170	46 7	—4 1
	11	48 6	11 24	179	48 2	—0 9
	12		11 16	173	46 1	—2 0
	13		11 23	176	46 9	—0 [illegible]
	14	48 7	11 02	163	44 8	—[illegible] 2
					Mean	—1 8

Mean values of calcium and percentage of standard (see Table 3) at each measured site

Site	4	5	6	7	8	9	10	11	12	13	14
	[illegible]	126 8	158 3	182 0	185 1	194 0	184 8	182 0	180 3	177 7	171 0

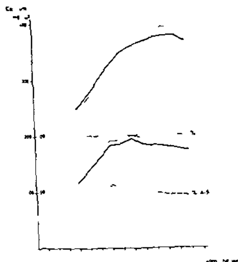


Fig 8 Calcium content in the radius of two subjects. The thick continuous lines represent the means of six readings (mg/cm² Ca) taken at 1 cm intervals between 4 and 14 cm from the wrist The thin continuous lines show the ranges of the six registrations at each site the thick broken line A S L represents the percentage of calcium using the mean values for B F as 100 % The thin broken lines indicate the percentage range of the six registrations.

that the error of reproducibility in the mean of a series of 11 readings was ± 1 4 % in both instances and that the mean of the two measurement series (22 readings) had a reproducibility error of ± 1 % (95 % confidence level)

Discussion

The apparatus described is of relatively simple design but to judge from the model experiments the measurement technique seems to produce a small measurement error about ± 0 7 % for the mean of 22 measurements For reasons already given a measurement error comparable to that obtained in the model experiments should apply when measuring an object consisting of compacta and soft tissue In addition to this the error at any particular location in the subject must also be considered Therefore the measurement reproducibility in human subjects must be such as to provide a good indication of the total measurement resulting in absolute values

The measurements should be made with the same light intensity (same working point) as that employed to balance the beams This is achieved by a servomechanism that regulates the anode current (mA of fluoroscopy) so that the intensity at the photo multiplier on the object side is held constant despite variations in density and thickness of the object

The role of the soft tissue in the total absorption is automatically cancelled out by employing the special slide rule

Comparative investigations on the absorptions of minced meat moistened with saline and of plexiglas as well as compacta and aluminium were in good agreement It may therefore be stated that the measurement in man should carry approximately the same error of method as in the model experiments Nevertheless a number of factors might have influenced these values, namely (1) faulty chemical determination of the calcium content in the pieces of compacta employed for construction of the compacta curve in Fig 3, (2) error in the soft tissue curve of Fig 3, e g due to absorbency differences between the meat saline mixture and soft tissue containing fat, muscle etc, or (3) an abundance of spongiosa in the measurement region

The accuracy of the chemical determinations depends on the number of tests For construction of the norm curve f_c, the calcium content was estimated in the form of mean values of four tests As stated earlier, the accord between the absorption of soft tissue and plexiglas was excellent

When the measurements are performed at locations characterized by much spongiosa, the roentgen absorption is reduced by the graininess of the spongiosa structures This error occurs however with all measurement methods, since it is a physical phenomenon and cannot be avoided According to HECK & SCHMIDT it can be as high as 10 % with a granular size of 1 mm The measurements in the present investigation were made in skeletal parts with a predominantly compact structure

The reproducibility of the measurement technique was confirmed by the results of calcium measurements in two subjects The deviation from the mean based on 22 readings was 1 %, which compares favorably with the $\pm$ 0 7 % error of method recorded in the model experiments

To obtain values reproducible in the same individual, and suitable for calculating the relative percentage of calcium based on standard curves, certain conditions are required, in particular well defined thickness and similar measurement sites over compact skeletal structures The specially constructed object holder satisfies the former requirement and measurement sites between 4 cm and 14 cm from the distal end of the ulna satisfies the latter requirement

The roentgenologic method described for determination of the calcium content in skeletal bone appears to be well suited for routine use The procedure is simple and requires only 15 minutes for a series of 11 readings Moreover, the results are readily available by conversion of the measurement values to mg cm Ca with the special slide rule Since there is a marked reduction in bone calcium related to increased age, normal curves should be established for different age groups Such standards are in the course of preparation in conjunction with a study of series of patients

Addendum in proof

Since this report was written a roentgenologic photometric method of measuring calcium in bone has come to our attention (EKMAN LJUNGQVIST & STEIN) Roentgen films at the two locations of the radius and ulna are scanned and the densities compared with the density of a simultaneously exposed standard The error of method per single measurement was found to be about 3 %

SUMMARY

A new method of estimating the calcium content of skeletal bone with a polychromatic roentgen source and two photo-multipliers is described The error of method was estimated in model experiments to be less than 1 % Preliminary measurements in the distal half of the human radius indicate that the calcium content can be determined with a reproducibility error of $\pm$ 1 % (95 % confidence level)

ZUSAMMENFASSUNG

Eine neue Methode zur Bestimmung des Kalkgehaltes der Knochen mittels einer polychromatischen Rontgen trahlenquelle und zwei Photoverstarker wird beschrieben Der Messfehler war weniger als 1 % Vorlaufige Messungen am unteren Ende des menschlichen Radius zeigten dass der Kalkgehalt innerhalb einer Genauigkeit von $\pm$ 1 % bestimmt werden kann Zuverlassigkeit 95 %

RÉSUMÉ

Les auteurs decrivent une nouvelle methode pour estimer le contenu en calcium de l os au moyen d une source polychromatique de rayons de roentgen et de deux photo-multiplicateurs Des experiences sur des modeles ont permis d estimer l erreur de cette methode inferieure a 1 % Des mesures préliminaires sur la moitié distale du radius de l homme montrent que la determination de la teneur en calcium est reproductible avec une erreur de $\pm$ 1 % (niveau de confiance 95 %

REFERENCES

ARI RAN G M Bone destruction not demonstrable by radiography Brit J Radiol 24 (1951) 107

BABIANTZ L Les ostéoporoses Radiol clin 16 (1947) 291

— Les ostéopathies atrophies J Radiol 29 (1948) 333

BARNETT E and NORDIN B E C The radiological diagnosis of osteoporosis A new approach Clin Radiol 11 (1960) 166

— — Radiological assessment of bone density Brit J Radiol 34 (1961) 683

CAMERON J R and SORENSON J Measurement of bone mineral in vivo An improved method Science 142 (1963) 230

— O CONNOR R KNUTZEN D and MAZESS R B Accuracy of bone mineral measurement Science 145 (1964) 338

EKMAN B LJUNGQVIST K G and STEIN U (1969) Personal communication

FROMMHOLD W und SCHOKNECHT G Untersuchungen uber die Absorption und Feinstruktur von Knochen mittel monochromatischer Rontgenstrahlung Fortschr Rontgenstr 93 (1960), 358

GERSHON COHEN J, CHERRY N H and BOEHNKE M Bone density studies with a gamma gage Radiat Res 8 (1958) 509

GRAN S M An annotated bibliography on bone densitometry Amer J clin Nutr 10 (162), 59

HEUCK F und SCHMIDT E Die quantitative Bestimmung des Mineralgehaltes der Knochen aus dem Rontgenbild Fortschr Rontgenstr 93 (1960) 523

— — Die praktische Anwendung einer Methode zur quantitativen Bestimmung des Kalksalzgehaltes gesunder und kranker Knochen Fortschr Rontgenstr 93 (1960) 761

JACOBSON B Development of dichromography techniques Publ Hlth Serv Grant No A—3910 (1963)

MAYER E H FROSTLE H G ACKERMAN E et coll A scintillation counter technique for the X ray determination of bone mineral content Radiat Res 13 (1960) 156

PRICE W A The science of dental radiology Dent Cosmos 43 (1901) 483

VIRTAMA P Determination of the mineral content of human finger bones by silver analysis of roentgenograms Acta anat 31 (1957) Suppl No 29

VOSE G P Quantitative determination of osseous and soft fractions of bone by X ray absorption Lab Invest 8 (1959) 1540

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EFFECT OF SECRETIN IN CELIAC AND SUPERIOR MESENTERIC ANGIOGRAPHY

by

ROLF UDEN

Pancreatic angiographies are usually performed with the pancreas at rest as a result of fasting and premedication Inactivity implies low oxygen consumption of the pancreas during the examination

Oxygen uptake in the pancreas can be increased by the intravenous administration of secretin (JORPES 1966 JORPES & MUTT 1959 LAGERLOF et coll 1967) During recent years pure crystalline secretin has been successfully produced and since 1966 synthesis is possible Secretin acts as a catalyst in the production of bicarbonate and water by the pancreatic cells as well as in the production of enzymes though to a lesser degree One clinical unit of secretin per kg body weight administered intravenously increases the oxygen uptake in the pancreas from the state of rest to 4 or 5 times within 3 minutes. The secretion from the pancreas to the duodenum following its intravenous injection starts at 3 minutes to become maximal at 10 to 30 minutes The greater oxygen consumption of the pancreas is associated with an increase in blood flow

TAYLOR et coll (1966) in pancreatic angiography with administration of intra arterial secretin in three normal cases reported that the pancreatic arteries were well demonstrated BENNET et coll (1967) in an investigation of 33 patients

Submitted for publication 19 November 1968

Table 1

Comparative studies of the diameter of the gastroduodenal artery the proper hepatic artery and the portal vein in fifteen combined celiac and superior mesenteric angiograms and five celiac angiograms without and with secretin stimulation

	Without secretin (mm)	With secretin (mm)
The gastroduodenal artery	3 8 (range 2—5)	4 8 (range 2—6 5)
The proper hepatic artery	5 4 (range 1—8)	5 3 (range 1—7 5)
The portal vein at maximum contrast filling	15 8 (range 10—20)	17 6 (range 12—22)

seventeen of whom had pancreatitis and one with carcinoma of the pancreas, stated that failure to outline the pancreas during the capillary phase following the administration of secretin was pathologic They added that the arterial phase is shortened and the pancreatic arteries become better contrast filled These authors apparently did not carry out control examinations without secretin in the individual subjects

The present investigation was performed during the period 1966—1968 to ascertain the effect of secretin on the vessels during angiography of the pancreas and whether favourable changes could be obtained for improving the diagnosis A preliminary report on ten cases was read at the 1967 March Meeting of the Swedish Society of Medical Radiology

Material The material consisted of 20 patients aged between 48 and 80 years, with a mean of about 65 years, and made up of twelve men and eight women No patients with acute or subacute pancreatitis were investigated with secretin because of the risk of activating the condition

All the patients were examined for probable carcinoma of the pancreas The following diagnoses were based on angiography, clinical studies, operation or autopsy Five patients had carcinoma of the pancreas and two had pancreatic cysts The pancreas was normal in thirteen patients One of these, however, was suffering from primary carcinoma of the liver, one from cirrhosis of the liver, one from carcinoma of the duodenum, and one patient had liver metastases from carcinoma of the colon

Methods

Angiographic examination technique and administration of secretin Selective angiographies were performed with MIKAELSSON (1965) catheters inserted after puncture of the femoral artery in the groin Combined celiac and superior



Fig 1 Case 20 Normal combined celiac and superior mesenteric angiography both films exposed 1.5 seconds after the start of contrast medium injections a) Without secretin b) With 75 clinical units of secretin injected into the celiac artery and the superior mesenteric artery 1.5 minutes before the contrast medium injection The following observations were made decreased reflux to the aorta widening of the gastroduodenal artery from 4 to 5 mm (←→) narrowing of the true hepatic artery and increased number of contrast filled small pancreatic arteries both in the head and body of the pancreas and faintly outlined gland (←)

mesenteric angiography was performed in fifteen patients and celiac angiography alone in five patients For each angiography 50 ml of Urografin 60 % or 76 % were injected with automatic pressure equalization at 4 kg atmospheric pressure The catheters were Y coupled in the combined celiac and superior mesenteric angiographies

The film series were made to a standardized program with films obtained as follows 2 s for 4 seconds 1 s for 3 seconds and 1 s every third second for 15 seconds Each series thus continued during 20 seconds In one instance films were obtained with 2 s for 4 seconds and thereafter one film every third second for 18 seconds

The first angiographic series series 0 was obtained without prior secretin injection At least 15 minutes after series 0 usually at 30 minutes 75 or 150 clinical units of secretin were injected through the catheters half in each From 1 to 3 minutes later angiographic series I was obtained The two series were performed under identical conditions as regards injection pressure type and amount of contrast medium exposure data and film series

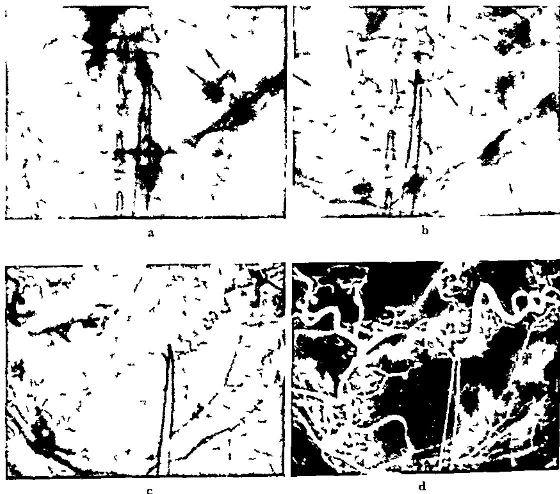


Fig. 2. Case 12. Normal combined celiac and superior mesenteric angiography without secretin 6 seconds after start of the contrast medium injection (a) and with 75 clinical units of secretin injected into the celiac artery and the superior mesenteric artery 2 minutes before the contrast medium injection (b, c, d). The film in (b) was exposed 6 seconds *after the start* of contrast medium injection and (c) is a subtraction film of (b). Maximal accumulation of contrast medium in the pancreas in both series in the films exposed 6 seconds after start of the contrast medium injection. In films (b) and (c) with secretin the accumulation of contrast medium in the pancreas is clearly seen (arrows) while without secretin (a) *there* is only slight accumulation of the medium. The subtraction film in (d) was obtained 2.5 seconds after the start of contrast medium injection. A great number of small dense pancreatic arteries are outlined and the gland is faintly outlined.

No premedication was given but before the investigation the stomach was inflated with carbon dioxide. (The examination was always supplemented with a right posterior oblique view, following the administration of cholecystokinin pancreozymin, alone or combined with secretin. This angiographic series is not included in this report but will be published later.)

Table 2

Comparative studies of mean transit time and range of values (in parentheses) in fifteen combined celiac and superior mesenteric angiograms and five celiac angiograms without and with secretin

	Time in seconds after start of contrast injection	
	Without secretin	With secretin
Appearance of contrast medium in a small artery of the pancreas identifiable in both series	1.5 (0.5—2.5)	0.9 (0.5—1.5)
Appearance of contrast medium in the portal vein	9.3 (5—18)	7.0 (3—15)
Maximal contrast filling of the portal vein	16.7 (9—21)	13.1 (9—18)

Recording of width and contrast filling of the vessels. The diameter of the gastroduodenal artery and of the true hepatic artery were used as parameters for the arterial phase. The diameter of the gastroduodenal artery was measured 1 cm from its origin and the measurements were made on the first roentgenograms in which contrast filling of one of the small pancreatic arteries was demonstrable in both series. The diameter of the true hepatic artery was determined from the same films.

The number and width of the small pancreatic arteries and the accumulation of contrast medium in the pancreas during the capillary phase — pancreatographic effect — were estimated and classified in degrees of 1 to 4, from small to large, and used as parameters for the capillary phase.

As parameter for the venous phase the diameter of the portal vein was measured in each series on the film in which the contrast density in the portal vein was maximal.

The density of the contrast medium in a vessel does not only depend on the width of the vessel but also on the concentration of the contrast medium which in its turn depends on the amount of medium injected per unit of time and the rate of blood flow.

The film with maximal contrast density of the portal vein in each series was used for measuring the width, as mentioned above, and for recording the rate of blood flow. GREITZ & SVK (1968) have shown that such a visual evaluation is as satisfactory as densitometric methods. The degree of maximal density in series 0 and series I was compared.

Recording of the blood flow rate. Two films per second were obtained during the first 4 seconds. The pressure injector was so adjusted that the first and second films were obtained without contrast medium to enable subtraction. The third

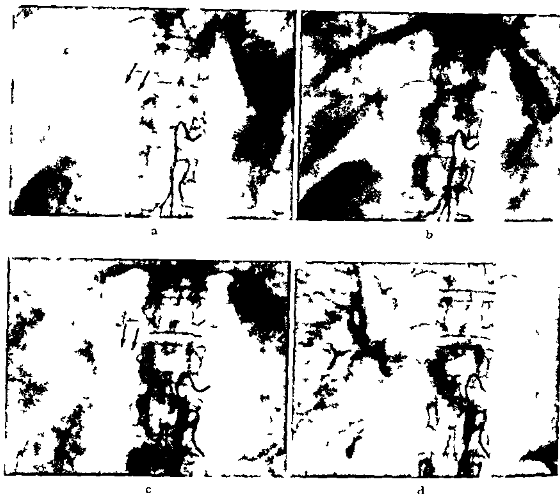


Fig 3 Case 6 Cyst of head of pancreas combined celiac and superior mesenteric angiography without secretin (a b) and with 75 clinical units of secretin injected into the celiac and the superior mesenteric artery one minute before the start of contrast medium injection In the film without secretin (a) the contrast medium appeared in the portal vein (←) 10 seconds after the start of contrast medium injection and with secretin (c) after 5 seconds Maximal filling of the portal vein without secretin (b) was obtained at 19 seconds and with secretin (d) at 16 seconds the contrast filling of the vein increasing after administration of secretin The portal vein and the superior mesenteric vein are displaced medially by the pancreatic cyst

film could thus be fully exposed at the earliest half a second after the start of injection For a comparison of the blood flow rates in two series performed in exactly the same way the absolute time is of less interest than the difference in time The third film was therefore regarded as exposed at half a second after starting the injection

The time required for filling of a small pancreatic artery identifiable in both series, served to determine changes in the blood flow rate during the arterial phase A branch of the arcade of the pancreas, or of the dorsal artery of the



Fig 4 Same case as in fig 3 Subtraction film with secretin of the arterial versus venous phase The arteries losely follow the portal branches (→→) in the parenchyma but not in the hilum of the liver The cystic arteries are not accompanied by any portal branches and are thus identified (→)

pancreas or a similar artery, was selected The times required for the first appearance of contrast medium in the portal vein and for maximal filling of the vein were also recorded

Recording of reflux Reflux to the aorta from the celiac artery and the superior mesenteric artery was recorded Its degree was estimated and was classified from slight to large in degrees from 1 to 4

Results

Width and contrast filling of the vessels The vessels supplying the pancreas generally increased in width the mean increase in diameter of the gastroduodenal artery being from 3 8 mm in series 0 to 4 8 mm in series I (Table 1 and Fig 1) No widening of the true hepatic artery was observed

Improved demonstration of the pancreatic vessels and a more intense pancreatographic effect were obtained after the administration of secretin The fine pancreatic arteries increased both in number and width in all the patients Increased pancreatographic effect was obtained in 13 patients following the administration of secretin in five of these there had been no pancreatographic effect without secretin In seven patients no pancreatographic effect could be obtained either with or without secretin (See Fig 2)

The demonstration of the venous phase was improved in 15 patients. Both the diameter of the vessels and the contrast density increased in six of these patients and in nine of them either the diameter or the contrast density increased The diameter of the portal vein increased on an average from 15 8 mm to 17 6 mm Of the five patients in whom the venous phase was not improved three had carcinoma of the pancreas (Table 1 and Figs 3, 5 6 7)

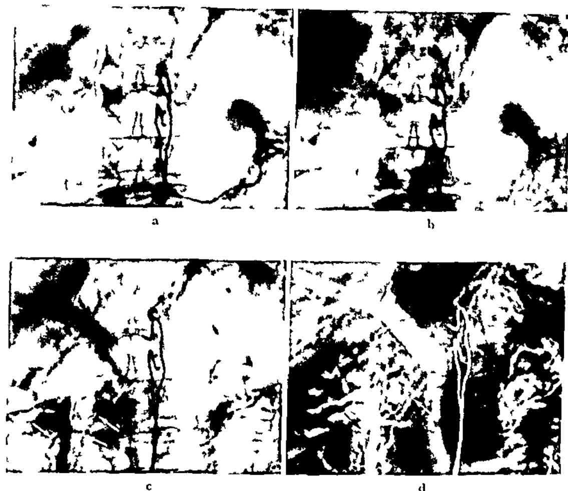


Fig. 5. Case 17. Normal combined celiac and superior mesenteric angiography without secretin at 10 and 16 seconds respectively after the start of contrast medium injection (a, b) and with 75 clinical units of secretin injected into both arteries 2 minutes before the contrast medium injection, the film being obtained 10 seconds after the start of contrast medium injection (c). Subtraction film of (c) is seen in (d). Maximal density of the contrast medium in the portal vein was obtained with secretin at 10 seconds (c) and without secretin (b) at 16 seconds; the better filling of the veins was obtained with secretin, thus enabling a study of the peripheral portions of the veins, for instance the pancreaticoduodenal veins (←) which are hardly visible without secretin (b). When there is maximal density of the portal vein with secretin (c) there is only slight filling without secretin (a).

Blood flow rate. The blood flow rate increased following the administration of secretin in the vascular areas that supply the pancreas, whereas the arterial phase in the liver often persisted longer after secretin (see Fig. 8). In series 0, without secretin, the small pancreatic artery selected was filled on an average at 1.5 seconds, and in series I, following the administration of secretin on an average at 0.9 seconds (Table 2).

The mean time for the appearance of contrast medium in the portal vein

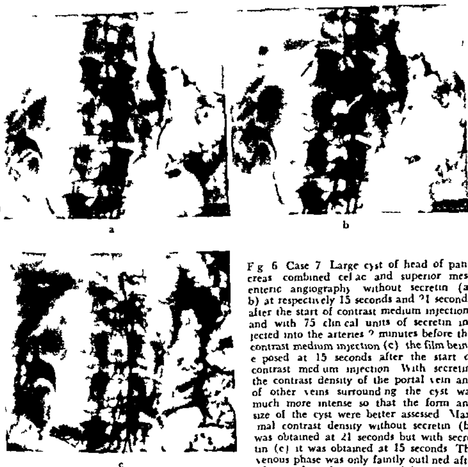


Fig 6 Case 7 Large cyst of head of pancreas combined celiac and superior mesenteric angiography without secretin (a b) at respectively 15 seconds and 21 seconds after the start of contrast medium injection and with 75 clinical units of secretin injected into the arteries 2 minutes before the contrast medium injection (c) the film being exposed at 15 seconds after the start of contrast medium injection With secretin the contrast density of the portal vein and of other veins surrounding the cyst was much more intense so that the form and size of the cyst were better assessed Maximal contrast density without secretin (b) was obtained at 21 seconds but with secretin (c) it was obtained at 15 seconds The venous phase was only faintly outlined after 15 seconds without secretin (a)

without secretin was 9 3 seconds and with secretin 7 0 seconds The maximal venous phase was present in the portal vein on an average at 16 7 seconds in series 0 and at 13 1 seconds in series I (Table 2 and Figs 3 5 and 6)

Reflux In 14 patients reflux to the aorta diminished after secretin or disappeared completely In four patients there was no reflux in either of the series and in two patients the reflux was equally large in both series No increase in reflux occurred in any of the patients after the administration of secretin (see Fig 1)

Influence of secretin on angiographic changes in carcinoma of the pancreas Venn diagrams were made for the purpose of studying the correlation between

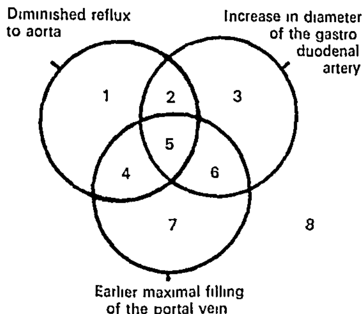


Diagram 1. Influence of secretin on the reflux to the aorta, on the blood flow rate and on the width of the gastroduodenal artery in the twenty patients analysed in the Venn diagram

Subset	Diagnosis	Number of cases
1	Carcinoma of the pancreas (1), normal pancreas (1)	2
2	Carcinoma of the pancreas (1)	1
3	Carcinoma of the pancreas (1), carcinoma of the duodenum (1), normal pancreas (1)	3
4	Carcinoma of the pancreas (1)	1
5	Cyst of the pancreas (2), normal pancreas (8)	10
6	Carcinoma of the pancreas (1), normal pancreas (1)	2
7		0
8	Normal pancreas (1)	1

reflux, blood flow rate and width of the vessels (FEINSTEIN 1964). Ten of the twenty patients ranged within all the three sets. Of the remaining 10 patients, five had carcinoma of the pancreas and thus came to be placed within one or two sets (Diagram 1).

In five patients with carcinoma of the pancreas, the radiographic criteria for the disease (LUNDERQUIST 1965) were more clearly demonstrated. A stenosed and infiltrated gastroduodenal artery was opened after the administration of secretin in one patient (Fig. 9). Pathologic vessels, both arteries and veins appeared earlier and were better filled following secretin (Fig. 7). Improved contrast filling of the tumor was obtained in two patients (see Figs 7 and 8).

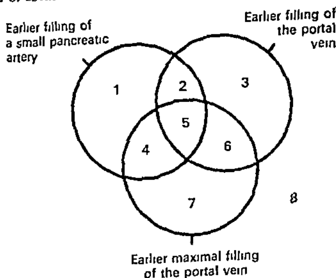


Diagram ? Influence of secretin on the blood flow rate in the twenty patients analysed in the Venn diagram

Subset	Diagnosis	Number of cases
1	Carcinoma of the pancreas (1) normal pancreas (?) carcinoma of the duodenum (1)	4
?	Carcinoma of the pancreas (1) normal pancreas (?)	3
3		0
4	Carcinoma of the pancreas (1)	1
5	Cyst of the pancreas (1) normal pancreas (7)	8
6	Carcinoma of the pancreas (1) cyst of the pancreas (1)	?
7		0
8	Carcinoma of the pancreas (1) normal pancreas (1)	2

It was not possible to find any connection between age sex amount of contrast medium injected and any of the parameters for blood flow rate or width of the vessels

Reactions to the drug Secretin caused a slight sensation of warmth in the epigastrium in most of the patients in a few combined with nausea. Three patients said spontaneously "It is the same feeling as after a nip Alcohol in the duodenum is considered to increase pancreatic secretion No significant changes were observed in the blood or serum diastase or in blood pressure or pulse

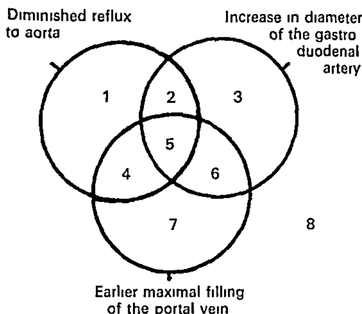


Diagram 1 Influence of secretin on the reflux to the aorta on the blood flow rate and on the width of the gastroduodenal artery *in the twenty patients analysed in the Venn diagram*

Subset	Diagnosis	Number of cases
1	Carcinoma of the pancreas (1) normal pancreas (1)	2
2	Carcinoma of the pancreas (1)	1
3	Carcinoma of the pancreas (1) carcinoma of the duodenum (1) normal pancreas (1)	3
4	Carcinoma of the pancreas (1)	1
5	Cyst of the pancreas (2) normal pancreas (8)	10
6	Carcinoma of the pancreas (1) normal pancreas (1)	2
7		0
8	Normal pancreas (1)	1

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Discussion

Following the administration of secretin both a shorter arterial filling phase and an earlier venous phase were generally noted In four patients however (Diagram 2) no change in the duration of the arterial filling phase was observed This discrepancy may be due to the fact that the method for measuring the time was not sufficiently refined since only two films per second were obtained In two of these four patients an earlier venous phase was observed but not in the other two

No difference in reflux to the aorta according to the 4 point scale was noted in six patients but changes in the blood flow rate or the width of the vessels were recorded (Diagram 1) Reflux had diminished in the other fourteen patients due to the fact that the celiac and the superior mesenteric artery can take up a larger amount of contrast medium during the same time or even during a shorter time

The contrast density of the veins increased following the administration of secretin which may be explained in three ways (1) a larger amount may have been injected during a shorter time on account of the diminished resistance in the vascular bed (2) the veins become wider which results in a thicker layer of contrast medium and (3) there may have been no time for the contrast medium to become diluted to a great extent through osmosis on account of its more rapid passage the possibility of identifying finer veins then augments (Fig 5) The venous phase in the portal vein was difficult to assess in one patient but distinct filling of the peripheral veins was obtained especially in series I (though this occurred also without secretin) The patient had extensive liver lesions primary hepatic carcinoma and probably portal hypertension

The effect of contrast media on the vessels has been discussed previously but ALMEN (1966) among others has reported that the effect of Urografin disappears after 5 minutes As the interval between the series without and with secretin in the present material was more than 15 minutes the differences between the two series cannot be explained as an effect of the contrast medium

The prior administration of bradykinin (BOIJSEN & REDMAN 1966) markedly affects the vessels generally within the entire area supplied by the celiac artery and the superior mesenteric artery The increased flow during the arterial phase

(Continuation of legend to Fig 7)
The tumor was partially concealed by the contrast filled renal pelvis The contrast density of the pathologic veins (↔) was considerably more intense and obtained earlier with secretin than without respectively at 9 seconds (d) and 10 seconds (c) The portal vein was wider with secretin than without (18 and 20 mm respectively) The maximal contrast density of the portal vein was in this case present at the same time i e at 12 seconds both with and without secretin but was more intense with secretin

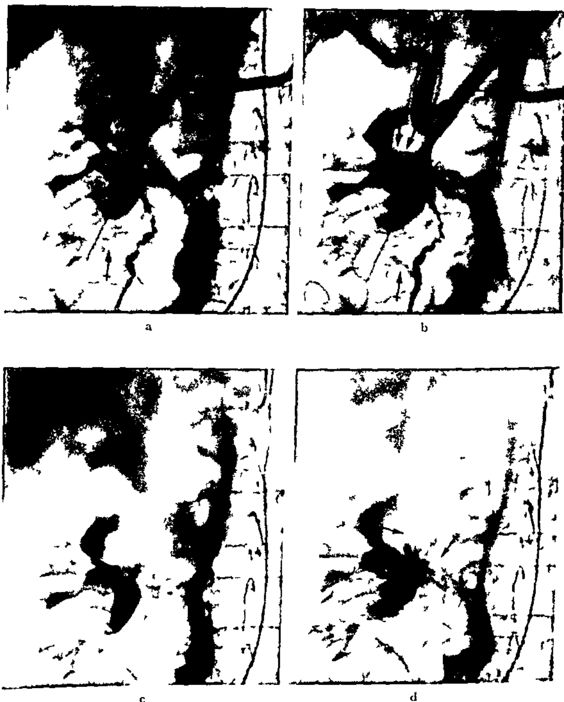


Fig. 7. Case 2. Carcinoma of head of pancreas; celiac angiography without secretin and films exposed at 3.5 seconds (a) and 12 seconds (c) after the start of contrast medium injection; with 75 clinical units of secretin injected into the celiac artery 1.5 minutes before and films exposed at respectively 3.5 seconds (b) and 9 seconds (d) after the start of the contrast medium injection. During the arterial phase with secretin (b) the contrast filling of the pathologic arteries was more intense (→→) and better filling of the tumor (→) than in (a) was obtained.
(For continuation of legend see p. 509.)



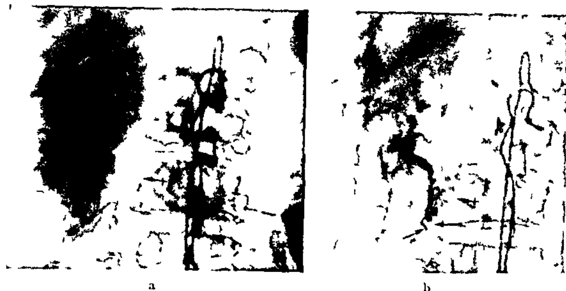
Fig 9 Case 5 Carcinoma of head of pancreas celiac angiography without secretin (a) and with 75 clinical units of secretin injected into the celiac artery one minute before the contrast medium injection (b) Without secretin (a) contrast filling was obtained only of the proximal part of the gastroduodenal artery (→) With secretin (b) the infiltrated and stenosed segment of the vessel was filled with contrast medium due to diminished peripheral resistance

a shorter time after the administration of secretin a higher degree of contrast density in the arteries capillaries and veins is obtained and lesions can be more readily demonstrated Better filling of the pathologic vessels is obtained in carcinoma of the pancreas and both neoplastic arteries and veins as well as the tumor are rendered more dense (Figs 7 and 8) Improved differentiation between the cysts and the surrounding parenchyma in pancreatic cysts is obtained by administering secretin (Fig 6)

BENNET et coll have stated that the absence of any pancreatographic effect following the administration of secretin is abnormal and signifies carcinoma or pancreatitis No pancreatographic effect occurred in the present investigation in four patients with a normal pancreas as indicated by angiography and clinical examination

Consequently the absence of a pancreatographic effect after secretin is not definitely pathologic On the other hand a pancreatographic effect was obtained following secretin in two patients with carcinoma of the pancreas and in two patients with pancreatic cysts

The pancreatic effect is only one of the parameters determining the effect of secretin on the pancreatic blood flow To be able to draw any definite conclusions at all from the absence of the effect of secretin on the flow it is necessary to study the changes in the width of the vessels and in the circulation time as well (Diagrams 1 and 2) Thus angiography of the pancreas must be performed both with and without secretin under otherwise identical conditions



a b

Fig 8 Case 1 Carcinoma of head of pancreas combined celiac and superior mesenteric angiography without secretin and film exposed at 6 seconds after the start of contrast medium injection (a) and with 75 clinical units of secretin injected into both arteries 1 25 minutes before and the film exposed 5 seconds after the start of the contrast medium injection (b) The accumulation of contrast medium in the tumor was more intense with secretin (→) and there was a higher degree of contrast density in the pathologic veins (↔) Both films represent maximal accumulation of contrast medium in the tumor in each series which was obtained one second earlier with secretin With secretin the contrast medium is still present in the hepatic arteries but has disappeared from the arteries of the pancreas and the bowel

is so extensive that the peripheral arterial details are lost' (BOIJSEN & REDMAN) After the administration of secretin, a selective effect on the pancreatic blood flow is obtained and the gastroduodenal artery, but not the true hepatic artery, is widened The peripheral resistance in the other celiac vascular areas persists and, consequently, the arteries during the shortened arterial phase maintain or increase their contrast filling in both the pancreas and in other areas following secretin, as opposed to the effect after bradykinin Despite this, a better venous phase is obtained even of the finest portal branches though not so marked as after bradykinin The excellent venous phase combined with the maintained arterial phase make it possible to obtain information about both the venous and the arterial phases at the same investigation A good example of this is the liver, where, by means of the subtraction procedure the arterial versus the venous phase and the interrelation of the two systems can be analysed in detail both in the hilum of the liver and far peripherally in the parenchyma, and vessels such as the cystic artery can be identified (Fig 4)

Since a larger amount of contrast medium can be supplied to the pancreas in

REFERENCES

ALMÉN T A steering device for selective angiography and some vascular and enzymatic reactions observed in its clinical application Acta radiol (1966) Suppl No 260

BENNET J CHÉRIGIÉ E. CAROLI J et coll La pancreatographie après stimulation par la sécretine intra artérielle Ann Radiol 10 (1967) 617

BOIJSEN E and REDMAN H Effect of bradykinin on celiac and superior mesenteric angiography Invest Radiol 6 (1966) 422

FEINSTEIN A R Scientific methodology in clinical medicine Ann intern Med 61 (1964) 564 757 944 1162

GREITZ T and SYK B Densitometric and visual evaluation of the circulation time in carotid angiography A methodologic study Acta radiol Diagnosis 7 (1968) 145

JORPES E Sekretin (In Swedish) Nord Med 67 (1966) 965

— and MUTT V Secretin and cholecystokinin pancreozymin (Cck Pz) Gastroenterology 36 (1959) 377

LAGERLÖF H SCHÜTZ B and HOLMER S Secretin test with high doses of secretin and correction for incomplete recovery of duodenal juice Gastroenterology 52 (1967) 67

LUNDERQUIST A Angiography in carcinoma of the pancreas Acta radiol (1965) Suppl No 235

MIKAELSSON C G Polythene catheter of new shape for percutaneous selective catheterization Acta radiol Diagnosis 3 (1965) 581

TAYLOR D MACKEN K and FIORE A Angiographic visualization of the secretin stimulated pancreas Radiology 87 (1966) 525

UDÉN R Coeliacomesentericografi efter sekretin (In Swedish) Nord. Med 78 (1967) 1465

Conclusions

The cause of diminished reflux, more rapid blood flow rate and widened vessels must be sought for in decreased peripheral vascular resistance. After the administration of secretin the capillaries are opened, so as to correspond to the increased oxygen consumption in the pancreas, and the glandular blood flow is increased. Thus, secretin affects the blood flow in the pancreas.

The two vascular systems of the liver may be studied in detail in the same examination after secretin stimulation, owing to the excellent venous phase in the portal vein and its branches, and to a well maintained arterial phase in the liver.

Carcinoma and cysts of the pancreas are better demonstrated with secretin.

SUMMARY

Twenty patients were investigated by combined celiac and superior mesenteric angiography both with and without prior intraarterial injection of secretin. The secretin increased the blood flow through the pancreas, as well as the width and contrast density of the pancreatic vessels. The excellent filling of the portal vein and its branches makes a study of the two vascular systems of the liver possible in the same examination. Carcinoma and cysts of the pancreas are well demonstrated with secretin.

ZUSAMMENFASSUNG

Kombinierte Angiographie der A. coeliaca und der A. mesenterica superior wurde mit und ohne vorherige intra-arterielle Injektion von Sekretin bei 20 Patienten vorgenommen. Das Sekretin führte zu einem gesteigerten Blutstrom durch den Pankreas, sowie zu erweiterten Pankreasgefässen und zu verstärkter Kontrastmitteldichtigkeit. Durch die gute Füllung der V. portalis und ihrer Äste war es möglich die beiden Gefäss-Systeme der Leber während derselben Untersuchung darzustellen. Carcinome und Zysten des Pankreas konnten mittels Sekretin gut sichtbar gemacht werden.

RÉSUMÉ

L'auteur a examiné vingt malades par angiographie coeliaque et par angiographie mésentérique supérieure associées avec et sans injection intra-artérielle préalable de sécrétine. La sécrétine augmente le débit sanguin dans le pancréas, le calibre des vaisseaux pancréatiques et la densité du moyen de contraste. L'excellent remplissage de la veine portale et de ses branches permet l'étude des deux systèmes vasculaires du foie au cours du même examen. Les cancers et les kystes du pancréas sont bien mis en évidence grâce à la sécrétine.

in adults In nineteen children all under 8 years of age, the gas disappeared within 24 hours after laparotomy, in only three cases was there any sign of gas in the abdominal cavity 30 minutes after the operation These investigators also injected 10 to 110 ml of air into the abdominal cavity during laparotomy in twelve children aged between 8 weeks and 8 years After 48 hours, nine of them had no signs of gas and in the remaining three only traces were visible

Two cases of perforation following laparotomy have drawn our attention to the question of the rate at which gas normally disappears from the abdomen after this intervention

Case reports

Case 1 Boy aged 14 months in whom esophageal atresia had been diagnosed at birth An upper esophageal stump had been exposed on the neck and a Witzel fistula created It was decided to reconstruct the esophagus later This was done with the aid of the ascending colon when the infant was 14 months old Four days later as his condition seemed unsatisfactory conventional roentgenography of the abdomen was carried out A moderate amount of free gas was present in the abdominal cavity and the small intestine was slightly distended with fluid levels suggestive of ileus The gas ought to have disappeared according to HOPE & CRAMER, 4 days after the laparotomy Perforation therefore seemed to be a likely cause of the pneumoperitoneum Re operation revealed defects in the suturing of the cologastrostomy

Case 2 Boy aged 2 days with fecal vomiting The meconium had been passed Conventional roentgenography of the abdomen revealed ileus malrotation and bandlike adhesions between the duodenum and small intestine were revealed at operation The after course was not wholly satisfactory signs of meteorism appearing after 5 days Repeat roentgen examination of the abdomen revealed a moderate amount of free gas and ileus From *the experience gained in Case 1 perforation was diagnosed and confirmed at the* subsequent operation

HOPE & CRAMER in their series of twelve cases of experimental pneumoperitoneum found no variation in the resorption time in patients whose ages ranged from 8 weeks to 8 years The age at which older children have the same resorption time as adults in postoperative pneumoperitoneum was not investigated

As it seems unlikely that the resorption capacity changes suddenly at some time during the period between childhood and maturity it was considered that a more thorough investigation might throw light on how the resorption time alters during growth If the conclusion reached by HOPE & CRAMER were correct such changes could be expected to take place after the age of 8 years. At roentgen examinations carried out in all cases of laparotomy immediately after the intervention and while the patients were still on the operation table only small amounts of air could be detected in most cases and in some cases no air at all

FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR HARRY LARSSON) AND SURGERY (DIRECTOR GUSTAF PETTERSSON) OF THE CHILDREN'S HOSPITAL, GOTHENBURG, SWEDEN

RESORPTION OF POSTOPERATIVE PNEUMOPERITONEUM IN CHILDREN

by

FRED SVARTHOLM and NICOLAUS ZWETNOW

The resorption time of the air entering the abdomen at laparotomy was first studied by LAURELL (1922) In two of his eight cases subjected to laparotomy, the gas took up to 3 weeks to disappear BANNEN, in 1944, reported that postoperative pneumoperitoneum disappeared within 7 days, and in 1945 stated that small amounts of gas were resorbed within 24 hours, while larger amounts took up to 14 days FRIMANN DAHL (1960), who investigated cases following laparotomy, noted that the gas was generally resorbed after 6 to 10 days but that up to 4 weeks sometimes elapsed before it disappeared According to COCCHI's (1952) observations, resorption of the gas took place within a few days while ZUPPINGER (1952) reported that gas was present for a week or longer after every laparotomy HARRISON et coll (1957) demonstrated that the duration of a postoperative pneumoperitoneum stands in direct proportion to the original amount of air They found that after gastrectomy all the gas was resorbed within 11 days, the only exception being a patient of asthenic body type with pulmonary tuberculosis, in whom the gas took 23 days to disappear HOPE & CRAMER (1958) were the first to report that the resorption time was shorter in young children than

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escape of air Roentgen examinations were then carried out at 6 hour intervals till the air in the abdominal cavity had disappeared

Statistical analysis The material consisted of 46 children, 15 boys and 31 girls, ranging in age from 4 to 16 years To find the relation between age (x) and resorption time (y) the regression between variables was analyzed It was found that

$$\bar{y}_x = 69\ 74 + 3\ 96\ (x - 11\ 52)$$

where the coefficient 3 96 indicates that the resorption time increased by 3 96 hours for each year of life The correlation between time increase and age was highly significant A t test of coefficients gave the level $p < 0\ 001$ All the relevant values for age resorption time and regression line as well as an upper normal limit for the resorption time are given in the accompanying diagram At the upper age limit of 16 years, the resorption time was about the same as in adults

The statistical analysis of the material and the short intervals between the different roentgen films gave more clearly differentiated results as regards the resorption time than have been obtained in earlier investigations This explains why the present writers unlike HOPE & CRAMER recorded a significant relation between age and resorption time

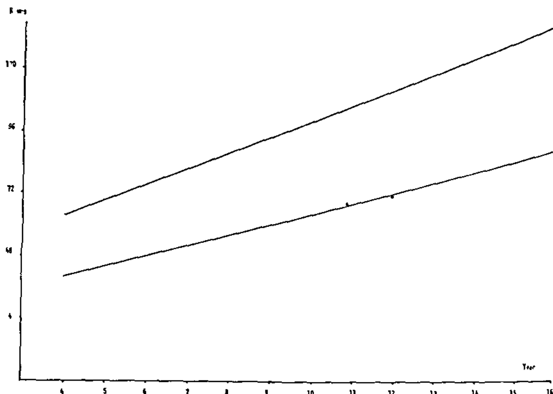
This study since it has revealed the upper limit at different ages for the resorption of 60 ml of air in the abdomen has provided a reliable basis for deciding whether signs of air leakage should be an indication for a second laparotomy Such a large amount of air as 60 ml has not been observed following laparotomy either by the present or by any previous investigators In practice therefore the upper limit mentioned might be reduced slightly The material comprises only cases with an ordinary postoperative course It contains no cases with a postoperative fall in blood pressure or with purulent peritonitis in which the air is probably resorbed at a slower rate

Acknowledgement

The authors take this opportunity of thanking E Carlstrom of the Department of Statistic Gothenburg University who performed the statistical analyses

SUMMARY

Postoperative pneumoperitoneum has been studied in 46 children ranging in age up to 16 years A statistically significant relation between resorption time and age was established The former was found to increase by 3 96 hours per year of life



Relation between age and the time taken for resorption of 60 ml of air in uncomplicated cases of postoperative pneumoperitoneum The regression line

$$\bar{Y}_x = 69.72 + 3.96\,(X - 11.52)$$

is given together with an upper 95 % normal limit $\bar{Y}_x + 1.64\, x$

In order to be able to determine the resorption time at different ages, 60 ml of air were injected in all cases of uncomplicated appendectomy after the abdomen had been closed The following procedure was adopted

After removal of the appendix, a No 12 Nelaton catheter was introduced *through a separate opening in the abdominal wall, and the abdominal wound* was then closed in layers with interrupted sutures The Nelaton catheter was fixed with a deep U suture of wire Air was injected through the catheter with a Record syringe, while at the same time a careful check was made by means of a layer of fluid over the operation wound to see that no air escaped during the injection *The catheter was fixed by double ligation and a roentgenogram* was obtained to determine the intraperitoneal position of the air The catheter was then removed, and the twisted U suture was drawn up tightly as soon as the tip of the catheter had been withdrawn from the operation wound A further check was made with a layer of fluid over the operation wound to *preclude*

escape of air Roentgen examinations were then carried out at 6 hour intervals till the air in the abdominal cavity had disappeared

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ZUSAMMENFASSUNG

Die Resorptionszeit des postoperativen Pneumoperitoneums wurde bei 46 Kindern im Alter bis zu 16 Jahren bestimmt Es wurde eine statistisch signifikante Abhängigkeit zwischen Resorptionszeit und Alter festgestellt Die Resorptionszeit verlangert sich um 3 96 Stunden pro Lebensjahr

RÉSUMÉ

Les auteurs ont étudié le pneumopéritoine postopératoire chez 46 enfants dont les ages allaient jusqu'à 16 ans Ils ont établi une relation statistiquement significative entre la durée de résorption et l'âge La durée de résorption augmente de 3 96 heures par année de vie

REFERENCES

BANNEN J E Postoperative pneumoperitoneum Brit J Radiol 17 (1944) 119
— Investigation of free gas in peritoneal cavity Brit J Radiol 18 (1945) 390
BROWNLEE K A Statistical theory and methodology in science and engineering Second edition John Wiley and Sons New York 1965
COCCHI U Pneumoperitoneum und Retroperitoneum *In* Lehrbuch der Rontgendiagnostik Funfte Auflage S 3474 Herausgegeben von H R Schintz Georg Thieme Verlag Stuttgart 1952
FRIMANN DAHL J Roentgen examination in acute abdominal diseases Second edition, p 50 Charles C Thomas Springfield Illinois 1960
HARRISON J LITWER H and GERWIG JR W H Studies on the incidence and duration of postoperative pneumoperitoneum Ann Surg 145 (1957) 591
HOPE J W and CRAMER H R The significance of post operative pneumoperitoneum in infants and children Radiology 71 (1958) 797
LAURELL H On pneumoperitoneum after operation Acta radiol 1 (1922) 520
ZUPPINGER A Das Zwerchfell *In* Lehrbuch der Rontgendiagnostik Funfte Auflage S 2593 Herausgegeben von H R Schintz Georg Thieme Verlag Stuttgart 1952

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LARYNGEAL FUNCTION IN LARYNGOCELE

by

AKOS KOVACS

A laryngocele consists of a dilatation of the appendix ventriculi which under normal conditions is present as an extension of the ventricle of Morgagni It is similar in shape to a thumb stall 5 to 10 mm long lined with ciliary epithelium and directed obliquely upwards A laryngocele is longer in children and usually undergoes regression after the sixth year if it persists it usually contains no air and its walls lie in close approximation Under pathologic conditions air may however enter the sac, particularly if this is longer and broader than usual a ventilation mechanism may sometimes become operative due either to swelling of the mucosa or to a neoplasm and dilatation of the sac may rapidly ensue It is believed that subjects in whom the laryngeal pressure is often increased, e g trumpet players glass blowers and chronic bronchitics may develop a laryngocele more frequently than others

A laryngocele if of small size remains below the false vocal cords but when dilated tends to move upwards in the aryepiglottic folds In 20 per cent of cases (WAVOFF) it breaks through the hyothyroid membrane and eventually through a weakened part of the thyroid cartilage it then becomes extralaryngeal and palpable between the muscles of the neck or under the skin

A laryngocele is phylogenetically identical with the laryngeal air sac of the

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ZUSAMMENFASSUNG

Die Resorptionszeit des *postoperativen* Pneumoperitoneums wurde bei 46 Kindern im Alter bis zu 16 Jahren bestimmt. Es wurde eine *statistisch signifikante* Abhängigkeit zwischen Resorptionszeit und Alter festgestellt. Die Resorptionszeit verlängert sich um 3.96 Stunden pro Lebensjahr.

RÉSUMÉ

Les auteurs ont étudié le pneumopéritoine postopératoire chez 46 *enfants dont les âges* allaient jusqu'à 16 ans. Ils ont établi une relation statistiquement significative entre la durée de résorption et l'âge. La durée de résorption augmente de 3.96 heures par année de vie.

REFERENCES

BANNEN J. E.: Postoperative pneumoperitoneum. Brit. J. Radiol. 17 (1944), 119.
— Investigation of free gas in peritoneal cavity. Brit. J. Radiol. 18 (1945), 390.
BROWNLEE K. A.: Statistical theory and methodology in science and engineering. Second edition. John Wiley and Sons, New York 1965.
COCCHI U.: Pneumoperitoneum und Retroperitoneum. *In*: Lehrbuch der Röntgendiagnostik. Fünfte Auflage, S. 3474. Herausgegeben von H. R. Schinz. Georg Thieme Verlag, Stuttgart 1952.
FRIMANN-DAHL J.: Roentgen examination in acute abdominal diseases. Second edition, p. 50. Charles C. Thomas, Springfield, Illinois 1960.
HARRISON J., LITWER H. and GERWIG JR. W. H.: Studies on the incidence and duration of postoperative pneumoperitoneum. Ann. Surg. 145 (1957), 591.
HOPE J. W. and CRAMER H. R.: The significance of post operative pneumoperitoneum in infants and children. Radiology 71 (1958), 797.
LAURELL H.: On pneumoperitoneum after operation. Acta radiol. 1 (1922), 520.
ZUPPINGER A.: Das Zwerchfell. *In*: Lehrbuch der Röntgendiagnostik. Fünfte Auflage, S. 2593. Herausgegeben von H. R. Schinz. Georg Thieme Verlag, Stuttgart 1952.

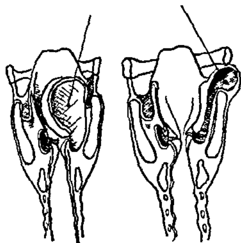


Fig 2 Schematic drawings of laryngoceles internal (left) and external (right)

the hyothyroid membrane to appear in the neck usually under the skin A mixed form when one external and one internal sac develop and a connection between the two persists has also been described The subdermal laryngocele consists of a soft tumour of variable size in the area demarcated by the anterior margin of the sternocleidomastoid muscle the clavicle the median line of the neck and the horizontal part of the mandible It is never attached to the skin or the deep tissues and can be easily compressed its contents which are either air or mucus can be squeezed out but the laryngocele rapidly refills An internal laryngocele may cause dysphonia, dyspnea and coughing

Just above a laryngocele the internal surface of the larynx is lined with normal mucosa, and at laryngoscopy the eminence caused by the laryngocele usually masks the ipsilateral vocal cord and arytenoid cartilage

Oblique asymmetric roentgenograms of the vocal cords during inflation of the larynx together with lateral views and tomography appear to be the most suitable methods for demonstrating a laryngocele Even small laryngoceles may be readily revealed by means of lateral and asymmetric films of the vocal cords Should the sac thus demonstrated contain air a differentiation from congenital cysts of the neck ectasia of the internal jugular vein hypertrophy of the plica ventricularis and fibromatous polyps must be made

The three complications that occur most frequently require careful investigation mechanical complications and those due to infection or tumour Disturbance of phonation or respiration by an internal laryngocele is said to constitute a mechanical complication If the laryngocele should become infected a phlegmon



Fig 1 Oblique asymmetric roentgenograms during phonation (left) and inflation (right) Only the appendix ventriculi is represented when the larynx is inflated the left ventricle continues in a short channel the left vocal cord is in the paretic paramedian position The upper line points to the piriform recess the arrow and middle line point to the appendix and the lowest line to the vocal cord

anthropoid apes In the orangutan, giant sacs arise from the larynx and extend under the skin to the axilla When the male of the species starts roaring the hills and the valleys echo with the noise The secret of the exceedingly loud sound lies in the resonating air sac that is blown up considerably during roaring

The roentgenologist must appreciate the anatomy of the structures from which a laryngocele arises The ventricle of the larynx is a sac shaped formation between the true and false vocal cords, laterally from this sac a quadrangular membrane, the lower thickened margin of which forms the false vocal cords, arises A laryngocele should not be confused with the piriform recess a similar sac, filled with air, which may extend deeply down to the ventricle of Morgagni or even deeper

The piriform recesses lie in the space delineated by the thyroid cartilage and are made up of two air containing sacs on both sides of the vestibule of the larynx Each is situated under the pharyngo epiglottic folds, lateral to the aryepiglottic plica, its oblique aperture is directed backwards It occasionally extends deeply behind the arytenoid muscle behind the level of the musculus vocalis (see Fig 3 a) When producing a low sound, the vestibule becomes wider, whereas the piriform recess narrows The latter dilates on high tone phonation Thus, the space of the larynx is filled jointly by the piriform recess and the vestibule of the larynx, although their dilatation and contraction are always opposed

Two types of laryngocele may be distinguished The so called internal type develops in the larynx and, when inflated, deforms the ventricular and aryepiglottic folds and eventually the vallecula The external laryngocele breaks through

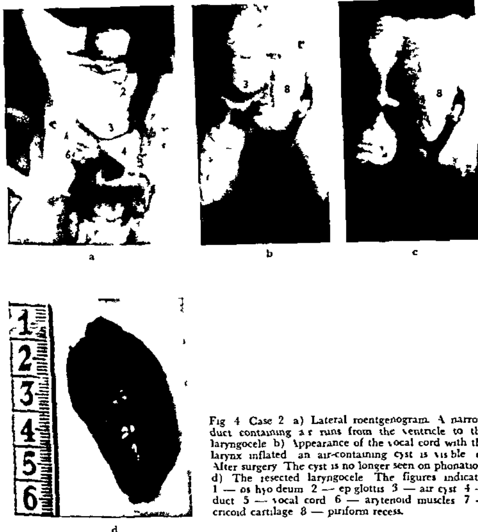


Fig 4 Case 2 a) Lateral roentgenogram. A narrow duct containing air runs from the ventricle to the laryngocele b) Appearance of the vocal cord with the larynx inflated an air-containing cyst is visible c) After surgery The cyst is no longer seen on phonation. d) The resected laryngocele The figures indicate 1 — os hyoideum 2 — epiglottis 3 — air cyst 4 — duct 5 — vocal cord 6 — arytenoid muscles 7 — cricoid cartilage 8 — piriform recess.

cartilage at the second level A laryngocele is often best revealed by a lateral roentgenogram obtained during a Valsalva manoeuvre The nostrils have to be completely closed by means of a clip and the patient instructed to make every effort to blow out the cheeks. Air filled cysts smaller than the ventricle of Morgagni should not be diagnosed as laryngoceles in films obtained under such conditions (see Fig 3 b)

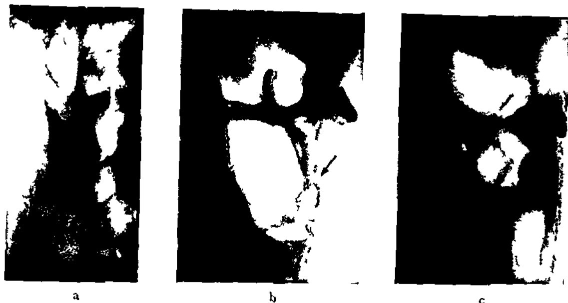


Fig 3 a) Piriform recess not connected with the ventricle b) Appendix ventriculi c) Fractured *epiglottis A narrow duct containing air runs from the ventricle to the laryngocele*

may develop inside the larynx A laryngocele and a laryngeal neoplasm may be associated Some authors believe that tissue tension caused by a tumour may increase pressure in the ventriculosaccular system or that a ventilation mechanism may become operative Others hold the view that the retention of fluid in a laryngocele may be a factor in the induction of malignancy Congenital predisposition must at any rate be considered This subject has been extensively dealt with by BONANDINI (1946), GUENZI (1951), MEDA (1952), LEBORGNE (1940), CHEVALIER JACKSON (1947), LEROUX ROBERT & ROGEON (1957), NOVOTNY (1954), FREEMAN (1952), BLAVIER (1957), PREOBRAZENSKI (1957) and BANHIDY (1967)

The roentgenologic examination of a laryngocele must be performed and evaluated with the utmost care The lateral films as well as those of the vocal cords have to be obtained during function, i e at least three roentgenograms during respiratory arrest, phonation, and while the larynx is inflated, or twelve in all Changes in the shape of the air column during function as well as the dynamics of the laryngeal ventricle must be carefully noted

If the abnormality is of considerable size and without complication a sagittal tomographic investigation usually suffices for the diagnosis WELIN (1954) has recommended that cuts be made at three to four levels, the first at 2 5 cm the second at 3 cm and the third at 4 cm below the skin surface The ventricle of Morgagni will be depicted at the first level and the region of the arytenoid



Fig 6 Case 3 The resected laryngocele and neoplasm

cords The left ventricle of Morgagni was not visible The piriform recess, lateral to the cyst was normal in width and extended down to the level of the vocal cords (Fig 4) Lateral films obtained during the Valsalva manoeuvre indicated that the cyst was about 4 cm in diameter when the larynx was inflated The appendix leading to the laryngocele was clearly seen Roentgenography ten days after operation revealed that the vocal cords met normally on phonation the left ventricle of Morgagni was well developed and that



Fig 7 Case 4 a) Irregular infiltration involving the right false and true vocal cords with a small pa te ma b) Small cyst below the hyoid bone c) Larynx inflated A cyst appeared and its duct also became visible

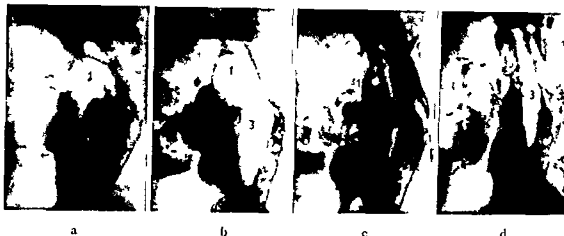


Fig 5 Case 3 a) An air containing cyst (1) and a small well defined dense mass (2) lie above the glottis b) Valsalva s manoeuvre revealed the piriform recess (3) and the widened laryngocele c) Forced phonation The dense mass retained its size whereas the laryngocele and the piriform recess became separate narrow slits d) Two months after removal of cyst and neoplasm

Case reports

Case 1 Girl aged *10* years had had difficulty in swallowing and breathing since she was four Tracheotomy had been performed when she was six years old so that she had intubation for 4 years she was admitted for closure of the stoma

Roentgen examination Lateral roentgenograms *with inflation of the larynx revealed that* the upper part of the epiglottis was bent backwards about 60 degrees and fixed against the posterior wall of the pharynx A narrow duct containing air arose from the ventricle of Morgagni and ran along the aryepiglottic fold where above the hyoid bone it became somewhat wider (Fig 3 c) It was assumed that the child had broken her epiglottis when she was four and that the injury had led to the development of the laryngocele

Surgical procedure The epiglottis was freed from adhesions and the cannula removed The laryngocele being small in size had caused no symptoms and was only a secondary finding

Case 2 Woman aged *61 with the* diagnosis of a *laryngeal tumour with metastases in* the left cervical region The patient had been hoarse for three months and had occasional dyspnoea during 2 to 3 weeks prior to admission She had recently noticed a lump in her neck *this had varied in size but had caused no pain Laryngoscopy* disclosed *no* abnormality of the nose epipharynx or pharynx A tumour just above the left ventricle of Morgagni was regular covered with mucosa and extended upwards to the aryepiglottic fold The right side was normal A further mass was present in the the left cervical region close to the anterior margin of the sternocleidomastoid muscle and at the level of the hyoid bone this extended to the left submandibular gland, was soft on palpation and was not adherent to the skin or deep tissues

Roentgen examination Oblique asymmetric roentgenograms indicated that the right vocal cord was normal but that the left was displaced slightly downwards although its surface appeared to be intact A cyst containing air about 1 2 cm in diameter lay just above the

smoker and had occasional difficulty in breathing Laryngoscopy revealed no abnormality of the epipharynx, nor pharynx but movement of the right side of the larynx was restricted An irregular increase in tissue extended from the laryngeal surface of the epiglottis involved the right aryepiglottic fold false cord and ventricle of Morgagni and reached the anterior commissure This caused considerable narrowing of the larynx

Roentgen examination Oblique asymmetric roentgenography revealed irregular infiltration of the right false and true vocal cords, with a small discrete mass lying above an irregular air filled duct directed outwards Fig 7 On inflation of the larynx, a small cyst was located in the lateral films situated just in front of the aryepiglottic fold (Fig 7 c)

Photography after the radical extirpation indicated that tweezers introduced from above *into the laryngocele could be pushed forwards into the ventricle* of Morgagni above which the verrucose tumour was clearly visible (Fig 8) Histologic investigation revealed carcinoma and laryngocele

Acknowledgements

The author would like to thank Drs Banhidy and Rethi who performed the operations and Dr Brasch who was responsible for the pathologic investigation, for their kind cooperation.

SUMMARY

The appendix of the ventricle of Morgagni and laryngoceles of small size can be well demonstrated in asymmetric roentgenograms of the vocal cords. Four cases of laryngocele in two of the cases associated with a malignant neoplasm are described

ZUSAMMENFASSUNG

Die Appendix des Ventrikels von Morgagni und kleinere Laryngocelen konnen in asymmetrischen Rontgenaufnahmen der Stimmbander gut dargestellt werden. Es werden vier Falle von Laryngocele beschrieben von denen zwei Falle auch ein malignes Neoplasm aufwiesen

RÉSUMÉ

L appendice du ventricule de Morgagni et les laryngoceles de petite taille peuvent etre bien mis en evidence sur des radiographies asymetriques des cordes vocales L auteur presente quatre cas de laryngocele dont deux etaient associés a une tumeur maligne

REFERENCES

BANHIDY F Laryngozele und Karzinom Z Laryng Rhinol *46 (1967) 619*

BLAVIER A Un cas de cancer du larynx associé à un laryngocele Acta oto-rhino-laryng belg 11 (1957) 307

BONANDINI B Laryngocele e cancero Valsalva *22 (1946) 105*

CATALDO J Giant laryngocele with epithelioma Med Radiogr Photogr 36 (1960) 66



Fig 8 Case 4 The cyst (→) and the neoplasm (+→) after removal

the cyst was no longer visible (Fig 4c) Histologic investigation of the resected laryngocele disclosed no evidence of malignancy (Fig 4d)

Case 3 Man aged 57 with a history of having possibly swallowed a foreign body A polyp had been removed 8 years previously from the left vocal cord since when his hoarseness had increased He was a heavy smoker

Laryngoscopy disclosed irregular swelling of the false vocal cord over the left true vocal cord The region of the ventricle of Morgagni appeared to be swollen

Roentgen examination A thin walled cyst containing air lay above the level of the upper margin of the thyroid cartilage behind a thickened left aryepiglottic fold A well defined dense mass about 1 cm diameter was situated just above the rima glottidis and involved the false but not the true vocal cords again above this a somewhat smaller air filled cyst was present Roentgenography with inflation of the larynx revealed considerable enlargement of the cyst Inferolaterally but clearly divided from it the piriform recess was visible Roentgenography with forced phonation demonstrated the small dense mass unaltered in size the laryngocele and the piriform recess then appeared as separate narrow slits however The diagnosis was neoplasm of the larynx with laryngocele (Fig 5)

The new growth and the laryngocele were removed (Fig 6) The histologic examination confirmed the diagnosis (planocellular carcinoma and laryngocele)

Oblique asymmetric films obtained two months after the operation demonstrated absence of the left vocal cord and hence the ventricle of Morgagni Otherwise no further evidence of abnormality

Case 4 Man, aged 59 with a diagnosis of neoplasm of the larynx had had hoarseness for more than six months and had recently lost about 5 to 6 kg in weight He was a heavy

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COMPUTER ASSISTED ANALYSIS OF RADIOGRAPHIC NECK LESIONS IN CHRONIC RHEUMATOID ARTHRITIS

by

WILLIAM M PARK and WILLIAM O BRIEN

Neck involvement may often become a serious problem late in the course of rheumatoid arthritis A convenient way of studying these abnormalities is by cineradiography we have found marked instability not only at the atlanto-axial joint but also at other levels In one patient in whom subluxation of the atlanto-axial joint greater than 1 cm was found the joint space slowly widened during flexion With extension however the joint remained wide until the plane of the atlas became horizontal At this point it suddenly snapped back against the odontoid process of the axis and the patient was aware of a click Subluxation of the second third and fourth cervical segments was also present during flexion In this particular patient there was in addition a prominent erosion on the posterior aspect of the axis Despite this gross instability the patient had little neurologic deficit or symptoms of vascular insufficiency during flexion

Although these are well recognised features of the condition we believe that all

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CHEVALIER JACKSON Laryngocele Laryngoscope (St Louis) 57 (1947) 788
FREEMAN J Three cases of infected laryngocele J Laryng 66 (1952), 409
GUENZI Laryngocele associated with cancer of larynx Arch ital Laring 59 (1951) 251
KOVÁCS Á Asymmetric roentgenography of the vocal cords Acta radiol 53 (1960), 426
— Roentgen physiology of the larynx Acta radiol 56 (1961) 433
LEBORGNE Tomography and cancer of the larynx Arch Otolaryng 31 (1940), 419
LEROUX ROBERT J et ROCLON A Tumeurs laryngées et laryngoceles Ann Oto laryng (Paris) 74 (1957), 885
MEDA Symptomatic laryngocele in cancer of the larynx Arch Otolaryng 56 (1952) 512
NOVOTNY O Maligne Degeneration einer Larynxzyste Mschr Ohrenheilk 88 (1954) 140
PREOBRAZENSKI I B Kehlkopfcarcinom kompliziert durch doppelseitige Laryngocele Vestn Oto rino laring 19 (1957) 115
WAYOFF Les laryngoceles Thèse de doctorat en medicine Nancy 1953
WELIN S Hypopharynx and larynx *In* Roentgendiagnostics Vol 4 Edited by H R Schinz et coll Grune and Stratton, New York 1954
ZOLLNER R Über das Kehlsackempyem Passow Schafers Beitr 30 (1932) 264

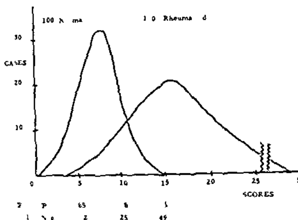


Fig 1 Discriminant scores for single neck roentgenograms taken in flexion and plotted against number of cases

rheumatoid arthritis for more than ten years These were matched for age and sex with a control group

The results are shown in Table 1 with indication of the levels of greatest involvement for each lesion Atlanto-axial subluxation was only found in the rheumatoid group in fact 22 % had subluxation greater than 5 mm Osteophytosis was commoner in the control group while vertebral plate erosion, inter vertebral subluxation apophyseal joint disease and spinous process erosion were more characteristic of rheumatoid disease Apart from spinous process erosion the rheumatoid lesions tend to involve higher levels than degenerative disease

Since there is some overlap between the two groups we analysed the results by means of Fisher s discriminant function In this way we were able to derive a score (for a single neck roentgenogram taken in flexion) which reflected weighting factors for individual lesions dependent upon their value in distinguish ing the two conditions

The scores obtained plotted against the number of cases are shown in Fig 1 No control subject had a score greater than 16 and no rheumatoid case had a score less than 3 Thus a score greater than 16 indicates definite rheumatoid arthritis and less than 3 normality In the overlap group it is possible to evaluate false positive and negative rates. At a score of 10 for example we would wrongly call 8 % of normal subjects rheumatoid ones and 25 % of the rheumatoid cases normal

Patients above and below a cut-off point score of 15 are compared in Table 2 Those with high values had such severe and continuous disease as to keep them off work and often requiring corticosteroid therapy More had a negative (less

Table 1

Prevalence of lesions in 100 patients with definite rheumatoid arthritis as compared to a control group of 100 normal subjects

	Rheumatoid patients		Control group	
	Per cent	Level	Per cent	Level
Atlanto axial subluxation (> 2 mm)	37		0 0	
Herniation of axis (> 5 mm)	19 7		14 7	
Osteophytosis	31	C4 6	50	C4 6
Plate erosion	21	C2 6	5	C4 6
Subluxation	24	C2 4	10	C2 4
Apophyseal erosion any level	59	C1 6	16	C6 7
Spinous process erosion	12	C6 7	2	C6 7

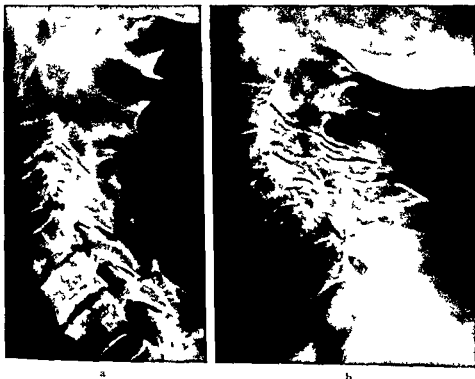
Table 2

Clinical course and analysis of neck roentgenograms for discriminant scores

	Scores	
	<15	>15
Severe continuous disease	15 %	39 %
Advanced subluxation of M C Ps	29 %	55 %
Multiple nodules	14 %	31 %
S C A T ten years ago		
Negative (less than 32)	35 %	11 %
High titre positives (greater than 256)	44 %	72 %
Haemoglobin less than gram %	18 %	61 %
Number of patients	49	51

such patients are at risk from sudden death, since two of our patients died directly as a result of rheumatoid neck disease Both were females and had severe generalised rheumatoid arthritis for many years The neck deformity with lateral flexion was so severe in one of the patients that she pleaded for surgical relief She unfortunately died on the operating table while an attempt was being made to strengthen her neck The second patient had severe atlanto-axial subluxation and tripped over a carpet at home She died instantly and at autopsy was found to have a separated odontoid process, which was found to be protruding into the foramen magnum and compressing the medulla

We have analysed the radiographic findings in 100 patients who had definite



a b

Fig 3 Two characteristic lesions of rheumatoid arthritis a) Vertebral plate erosion (may be of two types) Clear cut erosions reminiscent of peripheral arthritis are seen in C5 in C6 extensive erosion of the entire vertebral plates gives a hazy appearance There is in addition reactive sclerosis in adjacent vertebral bodies. b) Pencil sharpening of the spinous process of C6 with some erosion of processes C3 C4 and C5

are seen in Fig 3a This gives the body of C5 a dense appearance which is due to a reaction from the erosion of both its vertebral plates The spinous process erosion or sharpening seen in Fig 3b is also characteristic of rheumatoid disease

By the time neurologic deficit has occurred the anatomical lesion will have progressed far already and the question may be posed whether it be possible to predict the risks for these patients Obviously atlanto-axial subluxation is a major contributory factor We ran multiple regression analyses of atlanto-axial separation versus all other lesions It was found that factors which favour instability are intervertebral luxation vertebral plate erosion and apophyseal joint disease Disc space narrowing may be common to both groups but an association with osteophytosis is in favour of degenerative disease

We routinely take a cervical film in flexion of all our rheumatoid patients pre-





a b

Fig 2 a) Separation of 7 mm between atlas and axis due to involvement of the transverse ligament of the atlas The second third and fourth apophyseal joint spaces are narrowed with reactive sclerosis along the adjacent articular margins The body of C5 is slightly displaced posteriorly b) Odontoid process of axis completely eroded allowing the atlas to slip forward and tilt downward Normally the planes of the axis and atlas are parallel

than 1 in 32) S C A T ten years ago with conversion to high titre S C A T positives (greater than 1 in 256) at the present time

Atlanto axial joint instability may be due to laxity of the transverse ligament of the atlas, or to erosive destruction of the odontoid process of the axis or a combination of the two The first type is seen in Fig 2a, in which atlanto-axial separation of 7 mm is seen in the neutral position The subject should, of course, *always be examined in flexion as this may be the only position to show significant* atlanto-axial subluxation

A more severe type of abnormality is seen in Fig 2b The odontoid process has been completely eroded away and the forward slip is accompanied by a downward tilting of the plane of the atlas which now forms an acute angle with the plane of the axis

There are other characteristic lesions of rheumatoid arthritis These are shown in Fig 3 Large vertebral plate erosions accompanied by intense reactive sclerosis,

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ETUDE EXPERIMENTALE ET CLINIQUE DE LA TOLERANCE DES CAPILLAIRES CEREBRAUX POUR UNE NOUVELLE SUBSTANCE DE CONTRASTE (SELS DE L'ACIDE IOXITALAMIQUE)

par

R GONSETTE et G ANDRE BALISAUX

Dans un travail recent nous avons etudie l action sur les capillaires cerebraux de tous les produits de contraste commercialises actuellement

Nous avons utilise deux methodes d une part l observation des alterations de la barriere hemato-encephalique sur les autoradiographies apres injection de phosphore radioactif d autre part l etude anatomo-pathologique de leurs effets en microscopie électronique

Nous avons constate que leur toxicite propre c est a-dire liee a la nature chimique de l acide ne permet pas en angiographie cerébrale de depasser une concentration en iode de 300 mg ml Et encore faut il se mettre dans les meilleures conditions c est a dire utiliser le sel de methylglucamine en proportion maximale reduire au minimum la proportion du sel de sodium et enfin proteger ces solutions par l adjonction en proportion definie d un sel de calcium pour corriger le desequilibre ionique provoque par l injection des sels de sodium

Soumis a la Redaction le 14 novembre 1968

operatively, whether for peripheral synovectomy or relief of neck disease, to avoid the danger of hyperextending the neck during intubation and induction of anaesthesia by the anaesthetist in an unstable situation

To conclude, we feel that rheumatoid neck disease is a potentially lethal condition and that predictable patterns of involvement may become recognisable with regular radiographic examination

SUMMARY

The cervical films from 100 patients with definite rheumatoid arthritis for over ten years have been analyzed with computer assistance in an attempt to predict the risk of sudden death It is recommended that radiography of the cervical spine of all chronic rheumatoid patients be performed and that lateral films of the neck in flexion be obtained for assessing the instability before undertaking anaesthesia

ZUSAMMENFASSUNG

Cerebrale Rontgenogramme von 100 Patienten die Arthritis deformans seit mehr als zehn Jahren hatten sind mit Hilfe von einem Rechenautomaten analysiert worden um das Todesrisiko zu beurteilen Es wird empfohlen dass Radiographie fur alle Patienten mit kronischer Arthritis deformans durchgefuhrt werden soll und ferner dass man ein laterales Rontgenogramm vom Halse in Flexion schaffen soll um festzustellen bevor Anasthesie vorgenommen wird falls vertebrale Instabilitat vorliegt

RÉSUMÉ

Les auteurs ont examine les radiographies cervicales de 100 malades atteints de polyarthrite chronique rhumatismale confirmée evoluant depuis plus de dix ans et ont utilisé un ordinateur pour essayer de prevoir le risque de mort subite Ils recommandent de faire une radiographie de la colonne cervicale de tous les malades atteints de polyarthrite rhumatismale chronique et de faire des radiographies du cou de profil en flexion pour rechercher une instabilite vertebrale avant de procéder a une anesthesie générale

ment plus sensible et qui nous paraît à l'heure actuelle, donner les meilleures garanties d'innocuité.

Par ces diverses méthodes nous avons essayé de déterminer, par comparaison avec d'autres substances, la toxicité liée à la nature chimique de l'acide, la toxicité des différents sels et l'action protectrice des sels de calcium pour chacun d'eux.

Toxicité de l'acide. Pour déterminer la toxicité liée à la structure chimique de l'acide nous avons choisi le sel de sodium dont on connaît la forte toxicité. Nous en avons comparé les effets à ceux des sels de sodium des acides métrizoïque et iotalamique, substances récentes (1961—1962) et d'après nos expériences les moins toxiques parmi les produits de contraste actuellement utilisés.

A titre comparatif nous avons déterminé la concentration maximale en mg iode/ml tolérée par les capillaires cérébraux chez le cobaye par le test de la barrière hémato-encéphalique et en ultramicroscopie comme suit.

Acide (sel de sodium)	Lésions B.H.E. ^{32}P mg I/ml	Lésions (Mic. élec.) mg I/ml
Métrizoïque	240	200
Iotalamique	260	220
Acide 95 (ioxitalamique)	340	270

Tant par la méthode ultramiscoscopique que par le test au ^{32}P, l'acide 95 se caractérise par une tolérance meilleure des capillaires cérébraux en comparaison des dérivés des acides métrizoïque et iotalamique.

Toxicité des sels non protégés par le calcium. Dans une première série d'expériences nous disposions des sels de sodium et de méthylglucamine purs et du sel de monoéthanolamine associé soit au sel de sodium soit au sel de méthylglucamine. La concentration des solutions est de 380 mg I/ml.

La comparaison entre les sels de sodium et de méthylglucamine est résumée ci-dessous.

		Lésions de la B.H.E.	
		P	Mic. élec.
Solution 1	380 mg I/ml Na	++	+++
Solution 2	380 mg I/ml Mgl	0	+

Le sel de méthylglucamine de ce nouveau produit de contraste est infiniment mieux toléré que le sel de sodium. Mais étant donné sa forte viscosité il sera nécessaire d'y adjoindre du sel de sodium pour obtenir un produit de contraste utilisable en angiographie cérébrale. Nous avons étudié la proportion optimale sodium-méthylglucamine pour solutions à 380 mg I/ml.

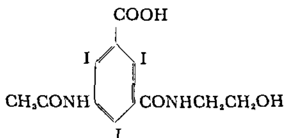
De plus, notre experience clinique en utilisant des produits opaques de viscosites differentes, nous a convaincus de ce que, en angiographie cerebrale, il ne faut pas recourir a des substances dont la viscosite depasse celle du sang (4 cP a 37°), sous peine d'obtenir un remplissage incomplet du systeme capillaire s'il existe une gêne circulatoire importante.

Nous avions par consequent pu conclure que pour depasser le seuil de 300 mg iode/ml il faut s'orienter vers des acides et des sels nouveaux.

Étude experimentale

Tous les produits actuellement utilises sont des sels d'acides triiodes avec differents substituants en positions 3 et 5 sur le noyau benzenique. Les diverses substitutions peuvent se traduire par des differences de tolerance.

Le produit de contraste faisant l'objet de ce travail est constitue de solutions de sels d'un acide nouveau : l'acide triiodo 2,4,6 acetylamino 3 N hydroxy-ethylcarbamyl 5 benzoique (acide 95 : ioxithalamique).



Avec ce produit on peut esperer depasser la concentration de 300 mg iode/ml en angiographie cerebrale. En effet, meme a des concentrations superieures, les solutions de certains sels de cet acide se sont revelees tres peu toxiques pour les capillaires cerebraux.

D'autre part, il est possible de preparer des solutions fortement concentrees du sel de monoethanolamine de cet acide. Ce sel doit allier en principe les avantages du sel de methylglucamine (bonne tolerance) a ceux du sel de sodium (viscosite faible). La combinaison de ces facteurs (modification de la formule chimique, sel nouveau) devrait aboutir a un produit de contraste bien tolere par les capillaires cerebraux, meme a concentration elevee et cela, malgre une viscosite basse en regard de la forte teneur en iode.

Nous avons applique a cette nouvelle substance les methodes utilisees pour les autres produits de contraste, c'est-a-dire la detection des lesions de la barriere hemato-encephalique par le passage du ^{3} P dans le parenchyme cerebral observees sur des autoradiographies et surtout l'observation en microscopie electronique de son action sur les capillaires cerebraux chez le cobaye, methode infini-

Tableau 1

Lésions de la B H E

mg iode/ml	Solution de sel Na		Solution de sel Na + sel Ca	
	P	Mic élec	P	Mic élec
380	+++	+++	+	+
340	0	++	0	±
300	0	+	0	0
260	0	0	0	0

Tableau 2

Lésions de la B H E

mg iode/ml	Solution de sel monoéthanolamine		Solution de sel monoétha nolamine + sel Ca	
	P	Mic élec	P	Mic élec
380	+	+	0	±
340	0	+	0	±
300	0	0	0	0
260	0	0	0	0

solutions de bases organiques (monoéthanolamine méthylglucamine) car la diffusion ionique est moindre en raison de la taille des cations et, peut-être de la conductivité des solutions De fait au cours d expériences antérieures, nous avons constaté que l action protectrice du calcium est nettement plus efficace pour les sels de sodium que pour les sels de méthylglucamine Cependant, pour des solutions de sels de méthylglucamine d acides plus toxiques que l acide 95 nous avons observé un effet protecteur discret mais indiscutable Il est vraisemblable que cette protection se situe dans ce cas directement au niveau de l endothélium capillaire

L action protectrice du calcium vis-à vis du sel de méthylglucamine de l acide 95 est difficilement appréciable étant donné sa tolérance excellente (360 mg/iode ml) A plus forte concentration la viscosité intervient comme facteur toxique (pour 380 mg iode ml la viscosité à 37 est égale à 13 cP) et sur ce facteur le calcium reste sans effet

En ce qui concerne le sel de sodium la protection des solutions par l adjonction de sel de calcium est particulièrement démonstrative pour l acide 95 tant par le test ^{32}P (forte concentration) que par l observation ultra microscopique (concentration plus faible) (voir Tableau 1)

		Lésions de la B H E	
		µp	Mic élec
Solution 3	1/2 Na/Mgl	0	+
Solution 4	2/1 Na/Mgl	+	++

Nous constatons que la balance Na/Mgl 2/1 dépasse nettement les limites de la tolérance des capillaires cérébraux Par contre, la balance inverse Na/Mgl 1/2 constitue un équilibre satisfaisant, indiquant dans quelle proportion il est possible d'adjoindre le sel de sodium au sel de méthylglucamine

Le sel de monoéthanolamine est étudié dans une première série d expériences en association avec ceux de méthylglucamine ou de sodium pour solutions à 380 mg I/ml

		Lésions de la B H E	
		µp	Mic élec
Solution 5	1/2 Eth/Mgl	0	+
Solution 6	2/1 Eth/Mgl	+	++
Solution 7	2 25/1 Eth/Mgl	++	+

Il est difficile de tirer des conclusions formelles de ces expériences Cependant, si le sel de monoéthanolamine semble moins toxique que le sel de sodium sa toxicité paraît se rapprocher davantage de celle de ce dernier que de celle du sel de méthylglucamine

Pour éclaircir ce point nous avons étudié la dose maximale, exprimée en mg I/ml tolérée par les capillaires cérébraux en ultramicroscopie pour chacun de ces trois sels

Ces expériences confirment la toxicité moindre du sel de monoéthanolamine par rapport au sel de sodium sans atteindre cependant la tolérance du sel de méthylglucamine, voir ci dessous

Sels de l acide iotalamique	*Concentration maximale (mg I/ml)* ne provoquant pas de lésions en mic élec
Sodium	270
Monoéthanolamine	320
Méthylglucamine	360

Protection des sels par l'adjonction de calcium Le mécanisme de la protection des capillaires cérébraux par les sels de calcium n est pas simple D une part, le calcium peut agir sur les cellules endothéliales elles-mêmes en améliorant leur résistance à un facteur toxique, d autre part, il peut agir en corrigeant le déséquilibre ionique brusque et important résultant de l injection rapide d un sel

En principe, ce déséquilibre ionique perdra son importance s il s agit de



Fig. 1. Angiographie vertébrale dans un cas de Steal syndrome. L'injection dans l'artère vertébrale gauche montre un reflux important dans l'artère vertébrale droite jusque dans l'artère sous-clavière.

La première formule (AG 57173) mise à notre disposition est une solution aqueuse à 38 % d'iode d'un mélange de sel de sodium, de monoéthanolamine et de calcium de l'acide 95. Sa viscosité à 37° est de 4,8 centipoises, légèrement supérieure par conséquent à celle du sang (4 cP). L'étude expérimentale de cette solution ne montre aucune altération des capillaires, ni sous l'aspect physiologique de la barrière hémato-encéphalique, ni sous l'aspect morphologique (ultramicroscopie).

Nous avons pratiqué 10 angiographies carotidiennes qui toutes ont été parfaitement tolérées, ne donnant lieu à aucune réaction d'ordre neurologique irritatif ou déficitaire. Par contre, nous avons constaté que l'injection intra-carotidienne de ces solutions était douloureuse, même diluées à 32 % d'iode. D'autre part, nous avons constaté qu'au delà d'une concentration de 34 % d'iode les images radiologiques devenaient moins lisibles par la forte opacité des

Pour ce qui regarde le sel le monoethanolamine, la tolerance au depart est meilleure que celle du sel de sodium, quoique inferieure a celle du sel de methyl glucamine Il est donc plus difficile d'apprecier l effet protecteur du calcium qui, en toute hypothese, semble moins important (voir Tableau 2)

Ces experiences confirment l hypothese de HOLTERMANN (SALVESEN, LUND & HOLTERMANN 1967) selon laquelle la principale action du sel de calcium est de corriger le brusque desequilibre ionique resultant de l injection massive d ions sodium

Lorsqu il s agit d un autre sel (monoethanolamine ou methylglucamine), le calcium trouve son utilite dans la protection directe de l endothelium vasculaire, surtout s il se trouve deja fragilise

Pour confirmer ce point de vue, nous avons realise des injections repetees de solutions de sel de methylglucamine pures et des solutions de sel de methyl glucamine protegees par des sels de calcium Nous avons constate qu il faut un nombre plus eleve d injections de solutions protegees que de solutions non pro tegees pour obtenir des lesions de la barriere hemato encephalique decelables par le test au ^{32}P Le calcium joue par consequent un role protecteur favorable lors que l endothelium a ete prealablement fragilise

Enfin, dans une derniere serie d experiences, nous avons etudie les effets resultant de l adjonction en plus du sel de calcium, des sels de magnesium et de potassium, a 380 mg I ml, comme suit

		Lésions de la B H E	
		^{32}P	Mic elec
Solution 8	Monoeth + Na + Ca	0	±
Solution 9	Monoéth + Na + Ca + Mg	0	0
Solution 10	Monoeth + Na + Ca + Mg + K	0	0

L adjonction du sel de magnesium semble avoir un effet protecteur supple mentaire vis a vis des capillaires cerebraux mais deja sans cela les solutions sont *si bien tolerees* qu il devient difficile d apprecier une difference quelconque

Experience clinique

Nos etudes experimentales chez l animal nous ayant convaincus de la su periorite incontestable du sel de l acide 95 sur le plan de la tolerance tissulaire locale par rapport aux produits de contraste actuellement disponibles et les ex periences de toxicite generale faites dans les laboratoires Andre Guerbet con firmant leur superiorite sur ce plan egalement, nous nous sommes crus autorises a utiliser ce produit de contraste chez l homme, pour des angiographies cere brales, carotidiennes et vertebrales

à 34 % d'iode en angiographie carotidienne pour acquérir la certitude que les solutions à 32 % d'iode seront parfaitement tolérées. Dans aucun de nos 100 cas nous n'avons observé de signes neurologiques, irritatifs ou déficitaires et cependant il s'agissait fréquemment de malades âgés ou présentant un réseau vasculaire fragilisé. Cette série préliminaire ne permet pas, à notre avis, de tirer des conclusions définitives mais elle nous semble suffisamment probante pour autoriser d'autres séries plus importantes.

Nous nous sommes surtout intéressés au problème de l'opacification des artères vertébrales dont le réseau vasculaire plus fragile donne parfois lieu après des angiographies à des complications graves (25 % d'incidents d'après TORMA & FOGELHOLM 1967). Elles résultent vraisemblablement de lésion de la barrière hémato-encéphalique dans le domaine des circulations vertébrobasilaires et cérébrales postérieures, dont les conséquences sont plus dramatiques qu'au niveau des hémisphères cérébraux. D'autre part, étant donné le calibre plus petit des vaisseaux et leur situation dans une zone où il est plus difficile d'obtenir un bon contraste radiologique, on est tenté de recourir pour ces examens délicats à des produits de forte teneur iodée mais de ce fait plus toxiques. C'est ainsi que TORMA utilise l'Urografin 45 % pour les angiographies carotidiennes et l'Urografin 60 % pour les angiographies vertébrales. Une nouvelle substance mieux tolérée, quoique plus radioopaque, nous semble par conséquent particulièrement intéressante dans ce domaine.

Nous avons pratiqué 50 angiographies vertébrales en utilisant la solution à 32 % d'iode de l'AG 58 95. Ces examens sont pratiqués sous anesthésie générale, par ponction directe de l'artère dans la région cervicale haute. Les clichés sont obtenus après injection de 5 ml, la quantité totale injectée étant de 10 ml (20 ml dans un seul cas).

Les premières angiographies furent pratiquées sans préparation particulière. Il ne semble pas que dans ces conditions l'AG 58 95 présente une supériorité évidente sur les autres produits de contraste en ce qui regarde le spasme de l'artère, principal écueil de cet examen (5 à 10 %). Par contre, au cours des 45 angiographies vertébrales successives pratiquées après injection intra-veineuse d'Hydergine suivant la technique de LEGRE et coll. (1966), nous n'avons observé de spasme artériel dans aucun des cas.

L'association d'une prémédication à l'Hydergine et de l'AG 58 95 comme substance de contraste a conféré à l'angiographie vertébrale dans notre service un caractère de simplicité et de sécurité comparable à celui de l'angiographie carotidienne. Ces examens ont cependant été pratiqués chez des sujets âgés (15 malades entre 60 et 69 ans, 10 malades entre 70 et 77 ans). Dans de nombreux cas il existait des signes d'insuffisance circulatoire vertébro-basilaire ou des symptômes d'hypertension intra-crânienne confirmés par un blocage du produit



a b

Fig 2 Angiographie vertébrale a) Malade présentant une thrombose de l artère carotide interne au niveau de la bifurcation On note une suppléance très importante de la circulation carotidienne a partir du domaine vertébro basilaire par l intermédiaire de l artère communicante postérieure b) Malade porteuse d un cancer du sein et présentant une symptomatologie cérébelleuse On observe la métastase hypervascularisée et située dans la partie basse de la fosse postérieure

temps capillaires Si des concentrations de plus de 32 % semblent utiles pour l étude de la micro-circulation dans certaines régions (artère ophtalmique), la concentration de 32 % nous paraît la meilleure pour l étude neuroradiologique vasculaire cérébrale de routine

Nos observations chez l animal paraissant indiquer que l élément douleur était dû a la présence du sel de sodium et a un moindre degré, du sel de mono éthanolamine, nous avons supprimé le sel de sodium et progressivement réduit la teneur du sel de monoéthanolamine en le remplaçant par celui de méthylglucamine La concentration reste fixée a 320 ou 340 mg/iode/ml et la viscosité est très proche de celle du sang

La solution qui nous a paru convenir le mieux est constituée pour 1 3 de sel de méthylglucamine et pour 2/3 de sel de monoéthanolamine (AG 58 95) D autre part, le sel de calcium ayant été jugé responsable de bouffées de chaleur par d'autres expérimentateurs, a été supprimé

La viscosité de ces solutions a 32 et 34 % d iode est respectivement de 3,9 et 4,5 cP a 37°

Nous avons pratiqué avec ces solutions 100 angiographies carotidiennes et 50 angiographies vertébrales Nous avons intentionnellement utilisé des solutions

a 34 % d iode en angiographie carotidienne pour acquerir la certitude que les solutions a 32 % d iode seront parfaitement tolerees Dans aucun de nos 100 cas nous n avons observe de signes neurologiques, irritatifs ou deficitaires et cependant, il s agissait frequemment de malades ages ou presentant un reseau vasculaire fragilise Cette serie preliminaire ne permet pas a notre avis de tirer des conclusions definitives mais elle nous semble suffisamment probante pour autoriser d autres series plus importantes

Nous nous ommes surtout interesses au probleme de l opacification des arteres vertebrales dont le reseau vasculaire plus fragile donne parfois lieu apres des angiographies a des complications graves (25 % d incidents d apres TORMA & FOGELHOLM 1967) Elles resultent vraisemblablement de lesion de la barriere hemato-encephalique dans le domaine des circulations vertebrobasilaires et cerebrales posterieures dont les consequences sont plus dramatiques qu au niveau des hemispheres cerebraux D autre part etant donne le calibre plus petit des vaisseaux et leur situation dans une zone ou il est plus difficile d obtenir un bon contraste radiologique on est tente de recourir, pour ces examens delicats a des produits de forte teneur iodee mais de ce fait plus toxiques C est ainsi que TORMA utilise l Urografin 45 % pour les angiographies carotidiennes et l Urografin 60 % pour les angiographies vertebrales Une nouvelle substance mieux toleree quoique plus radioopaque nous semble par consequent particulierement interessante dans ce domaine

Nous avons pratique 50 angiographies vertebrales en utilisant la solution a 32 % d iode de l AG 58 95 Ces examens sont pratiques sous anesthesie generale par ponction directe de l artere dans la region cervicale haute Les cliches sont obtenus apres injection de 5 ml la quantite totale injectee etant de 10 ml (20 ml dans un seul cas)

Les premieres angiographies furent pratiquees sans preparation particuliere Il ne semble pas que dans ces conditions l AG 58 95 presente une superiorite evidente sur les autres produits de contraste en ce qui regarde le spasme de l artere principal ecueil de cet examen (5 a 10 %) Par contre au cours des 45 angiographies vertebrales successives pratiquees apres injection intra veineuse d Hydergine suivant la technique de LEGRE et coll (1966) nous n avons observe de spasme arteriel dans aucun des cas

L association d une premedication a l Hydergine et de l AG 58 95 comme substance de contraste a confere a l angiographie vertebrale dans notre service un caractere de simplicite et de securite comparable a celui de l angiographie carotidienne Ces examens ont cependant ete pratiques chez des sujets ages (15 malades entre 60 et 69 ans 10 malades entre 70 et 77 ans) Dans de nombreux cas il existait des signes d insuffisance circulatoire vertebro-basilaire ou des symptomes d hypertension intra cranienne confirmes par un blocage du produit



Fig 3 Angiographie vertebrale a) *Malade* presentant des signes cliniques d insuffisance circulatoire vertebro basilaire On observe une augmentation considerable du tronc basilaire interessant aussi bien sa largeur que sa longueur (mega artere basilaire) et confirmant l arteriosclerose majeure dans ce domaine b) Malade presentant un petit meningiome occipital dont l irrigation se fait exclusivement à partir des artères cerebrale posterieure et cerebelleuse superieure L angiographie carotidienne etait normale dans ce cas

de contraste a l iodoventriculographie Chez aucun de nos 50 malades nous n avons *observe de modification de la symptomatologie clinique, en particulier* aucun signe neurologique nouveau, ni troubles de la conscience, pouvant faire craindre un oedeme cerebral Aucun des 50 malades n a presente de troubles visuels apres l angiographie

La teneur en iode de 32 % et une viscosite equivalente a celle du sang donnent un produit d excellentes qualites de contraste Les images radiographiques apres injection de 5 ml sont excellentes et superieures, a notre avis, a celles obtenues avec d *autres produits actuellement disponibles*

Quelques cliches angiographiques pratiques dans des cas de circulation vertebro basilaire precaire, illustrent d une part la qualite radiographique des images et d autre part, une tolerance parfaite du produit de contraste par ces malades Steal *syndrome* (Fig 1), *suppleance par le systeme vertebral* d une thrombose de la carotide interne (Fig 2a), arteriosclerose majeure (Fig 3a) Enfin, la persistance d un contraste *excellent sur les temps capillaires et veineux permettra* sans doute de mieux visualiser certaines tumeurs Nous presentons les cliches d une metastase visible des les premiers temps arteriels (Fig 2b) et d un meningiome occipital irrigue exclusivement par l artere cerebrale posterieure, invisible sur les angiographies carotidiennes (Fig 3b)

Conclusions

L etude experimentale chez l animal d un nouveau produit de contraste (acide ioxitalamique) realisee avec des methodes permettant de deceler la moindre in tolerance tissulaire locale provoquee par cette substance au niveau du systeme nerveux central et une premiere etude clinique apres injection intra carotidienne et intra vertebrale chez l homme permettent d affirmer que ce produit de con traste presente des avantages importants par rapport aux substances actuellement disponibles

Ces avantages concernent surtout la tolerance capillaire qui se montre infini ment meilleure malgre une concentration en iode elevee (320 a 340 mg/iode/ ml) Cette tolerance excellente est due en partie a la nature meme de l acide et en partie à l introduction dans la solution d un sel nouveau (monoethanolamine), remplaçant le sel de sodium La solution de ce sel possede une viscosite egale a celle du sel de sodium donc tres basse ce qui permet de l associer au sel de methylglucamine sans devoir recourir a l adjonction de sel de calcium pour la proteger

Le produit de contraste qui en resulte (AG 58 95) constitue un progres indiscutable car il reunit des exigences jusqu a present inconciliables à savoir une forte teneur en iode et donc d excellentes qualites de contraste une viscosite egale a celle du sang permettant de ce fait une etude non seulement radiographique statique mais dynamique et enfin aux concentrations proposees une absence de toxicite non seulement generale mais tissulaire locale

Une experimentation clinique plus large de cette nouvelle substance nous parait souhaitable

RESUMÉ

Les auteurs ont etudie chez l animal la tolerance des capillaires cerebraux pour une nou velle substance de contraste AG 58 95 L absence de toxicite locale de ce produit vis a vis des vaisseaux cerébraux a ete mi e en evidence par le test de la barriere hemato-encepha lique avec ^{3} P comme indicateur et l observation en ultra microscopie des capillaires et de leurs annexes Devant cette tolérance excellente malgre une concentration en iode elevée et une viscosité basse les auteurs ont pratique chez l homme 100 angiographies carotidiennes et 50 angiographies vertebrales avec l AC 58 95 Ils n ont observe aucune intolérance au produit de contra te au cours de ces 150 examens Ils en concluent que cette nouvelle substance mieux toleree quoique plus radioopaque constitue dans le domaine de l angio- gr phie vertebrale surtout un progres interessant

SUMMARY

The toleran e of a ne contrast medium AG 58 95 was tested in animals No local t xicity to the cerebral vessels was observed using ultramicroscopy and ^{3} P as indicator for studying the hemo- ncephalic barrier In view of this good tolerance despite the high iodine

content and low viscosity, the contrast medium was used in 100 carotid angiographies and 50 vertebral angiographies in human subjects. No single case of intolerance was observed in the course of these 150 examinations. The authors conclude that the new substance by being better tolerated although more dense represents an important improvement, particularly for use in vertebral angiography.

ZUSAMMENFASSUNG

Die Toleranz der cerebralen Kapillare auf ein neues Kontrastmittel AG 58.95 wurde an Tieren untersucht. Bei der Untersuchung der Blutliquorschranke mittels Ultramikroskopie und mit ^{32}P als Indikator konnte keine lokale Toxizität in den Gehirngefässen observiert werden. Mit Hinsicht auf die gute Toleranz trotz des hohen Jodgehaltes und der niedrigen Viskosität wurde das Kontrastmittel bei 100 Karotisangiographien und 50 Vertebralisangiographien an Menschen verwendet. Kein einziger Fall von Intoleranz wurde im Laufe dieser 150 Untersuchungen beobachtet. Die Verfasser meinen deshalb, dass das neue Kontrastmittel, obwohl von höherer Dichtigkeit, eine erhebliche Verbesserung besonders für die Vertebralisangiographie ist.

BIBLIOGRAPHIE

GONSETTE R. et ANDRÉ BALISAUX G. La perméabilité des vaisseaux cérébraux. Étude systématique de la tolérance des capillaires cérébraux pour les produits de contraste utilisés en artériographie. *In*: Cations in intravascular contrast media and development of specific metrizoate formulas. Pharmacologic and clinical studies. Acta radiol. (1967) Suppl. No 270, p. 228.

GUERBET M. et TILLY G. Communications personnelles, 1967.

KUTT H., VEREBELY K., BASC N. et coll. Possible mechanisms of complications of angiography. Acta radiol. Diagnosis 5 (1966) 276.

LABAUGE R., DU CAILAR J., MIARDEZ M. et coll. Cécité corticale après angiographie cérébrale. Réversibilité sous oxygénothérapie hyperbare. Rev. Neurol. 118 (1968) 283.

LEGRÉ J., WATEL J., SAID D. et coll. Traitement par l'hydergine du spasme de l'artère vertébrale au cours de l'angiographie par voie directe. Ann. Radiol. 6 (1966) 647.

SALVESEN S., LUND NILSEN P. and HOLTERMANN H. Ameliorating effects of calcium and magnesium ions on the toxicity of Isopaque sodium. I. Acute toxicities and toxicities in the brain. *In*: Cations in intravascular contrast media and development of specific metrizoate formulas. Pharmacologic and clinical studies. Acta radiol. (1967) Suppl. No 270, p. 17.

TORMA T. and FOGELHOLM R. Complications of cerebral angiography with Urografin. Acta neurol. scand. 43 (1967) 616.

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MICROVASCULAR EFFECTS OF TOPICALLY APPLIED CONTRAST MEDIA

by

P I BRANEMARK B JACOBSSON and S E SORENSEN

The toxicology of roentgen contrast media has received much attention in recent years and has been the subject of several investigations Side effects such as nausea vomiting and urticaria are not uncommon after the intravenous and intraarterial injection of contrast media the latter often also produce a more or less severe local burning sensation

Clinical observations have even indicated more serious effects. Coronary angiography is sometimes followed by electrocardiographic abnormalities (ROSS 1963 JACOBSSON & PAULIN 1967) Circulatory changes such as alterations in the minute volume blood pressure hematocrit and plasma volume and osmolality have been reported (BROWN et coll 1965 FODA et coll 1965 and ISERI et coll 1965) In the presence of reduced renal function damage to the kidneys as reflected in an increased NPN has been demonstrated after nephroangiography BALDISCH & BAUMANN 1964) Albuminuria following urography has been described KIRKLAND & HASLOCK 1961) INGVAR (1957) and CREITZ & WEISS 1959) during cerebral angiography with moderate amounts of contrast medium registered only a few changes in the EEG whereas LUNDERVOLD & ENGESET 1967) using larger doses of medium frequently observed such changes

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Both gross and microscopic lesions in the kidneys of dogs and rabbits following the use of large amounts of contrast medium have been reported by BERG et coll (1958), ARNESEN (1962), and RHEA et coll (1965) While BERG et coll considered Hypaque 90 % not injurious to the rabbit kidney, RHEA et coll, who studied dogs, stated that this medium produced various degrees of renal damage, such as haemorrhagic extravasation and massive areas of tubular necrosis with cellular dissolution In a comparative investigation of Urografin and Isopaque, ARNESEN demonstrated changes, e g shrunken glomerular tufts and albuminous transudate in Bowman s space, hyaline droplets in the proximal tubules and hyaline casts in the distal tubules of the kidney of the rabbit after the injection of contrast medium into the aorta Mild degenerative alterations in the proximal tubules and casts in the distal tubules could be demonstrated four weeks after the injection of the medium

By injecting various contrast media, Urokon, Hypaque and Angio-Conray, into the aorta of the dog with the spinal cord as the test site, MARGOLIS & YERASIMIDES (1966) demonstrated varying degrees of injury to the nervous system, ranging from scattered microscopic destruction affecting grey and white matter to extensive damage and disorganization

The mechanism of the above mentioned toxic effects on the various organs is still obscure It probably involves damage to the endothelium and the endothelial barrier, as demonstrated by the passage of trypan blue into the brain tissue and described originally by BROMAN & OLSSON (1948) The technique of BROMAN & OLSSON as modified by STEINWALL (1958) is still used for evaluation of the toxicity of modern contrast media (HAMMARGREN et coll 1965, SALVESEN et coll 1967)

After staining of the endothelium with silver nitrate solution (0 2 % to 0 25 %) a directly observable effect of contrast media on the vessel wall has been reported (ZINNER & GOTTLOB 1959, MERSEREAU & ROBERTSON 1961, AUSMAN et coll 1964, and MCCONNELL & MERSEREAU 1964) All the media examined caused some endothelial damage and its extent appeared to vary with the duration of exposure and the concentration and chemical structure of the agent

Besides the local toxic effect on the vessel wall vital microscopy has indicated that contrast media also produce considerable disturbances in the microcirculation

SCHMIDT (1955) was the first to describe circulatory disturbances in the pial arteries of the rabbit and cat after intracarotid injection of contrast medium The flow after the injection of Perabrodil M 80 % Joduron 70 % or Urografin 76 % was sometimes so slow as to lead almost to circulatory arrest, the medium sometimes flowed slowly to and fro in the pial arteries SCHMIDT also reported that the stasis occurs first in the small vessels and then continues in a retrograde

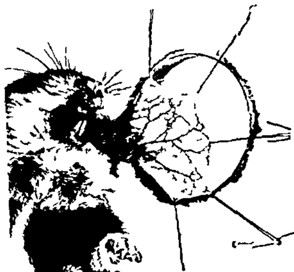


Fig 1 Bird s eye view of exposed cheek pouch of hamster

direction into the larger arterioles resulting in circulatory arrest of varying duration No circulatory disturbances were observed after the injection of lower concentrations of contrast media e g Perabrodil M 45 % Joduron 30 % Urografin 40 % or Thorotrast In extensive investigations of the toxic effect of Urokon (acetrizoate) on the medulla spinalis of the dog MARGOLIS et coll (1959) noted principally the same changes in the microvascular flow patterns as those described by SCHMIDT Besides the slowing down of the flow in the pial vessels they recorded an immediate clumping of red cells into granular masses after the intra arterial injection of Na acetrizoate 70 % Similar changes have been described by READ & MEYER (1959) who studied the microcirculation in the thigh mesentery and pia of the dog and cat JOHNSON & KNISELY (1962) who studied the mesentric arteries in frogs mice and rats and WIEDEMAN (1963) who used the wing of the bat as the object of study

It has thus been demonstrated that contrast media injected intravascularly have a toxic effect on the vessel wall as evidenced by the passage of trypan blue through the wall to indicate blood brain barrier damage Injury to the endothelium has also been disclosed by staining with silver solution Furthermore, vital microscopic studies have revealed considerable disturbances in microvascular physiologic functions. The functional interplay between the microcirculation and the tissue and the significance of the disturbance in the former

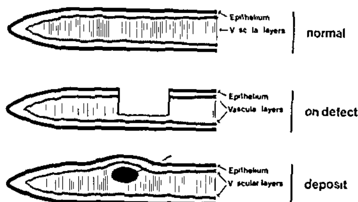


Fig 2 Diagrammatic representation of various experimental procedures The normal exposed cheek pouch small tissue defects and sites of application to the tissue

have not however been investigated in the studies so far performed Nor has the actual cause of such disturbance become known The hypertonicity of the media has been considered a possible cause of the local toxic effects but this assumption still remains to be proved The possible role played by the interaction of the mast cells and ground substance in the physiologic mechanisms has been almost completely overlooked The problems are complex and it therefore appears unlikely that one single method can completely clarify the causes of the disturbances in the microcirculation and the changes in permeability of the vessel wall

BRANEMARK (1967) BRANEMARK & GOLDIE (1967), BRANEMARK et coll (1966) in a series of investigations of tissue injury induced by different drugs applied on intact or more or less damaged microvascular systems, have shown the cheek pouch of the hamster to be well suited for screening purposes as well This appears also to be satisfactory for the detailed analysis of physiologic mechanisms related to blood cells, plasma endothelium, periendothelium as well as periendothelial and tissue mast cells Changes in the microcirculation in the cheek pouch after the topical application of contrast media were first described by JACOBSSON (1965)

As the further aim of the present study was to elucidate some of the still obscure tissue injury phenomena caused by contrast media, the vital microscopy of the cheek pouch of the hamster was selected as a suitable method for this investigation

Method and Material Hamsters weighing about 100 g were anaesthetized with nembutal 30 mg/kg i m The animal was immobilized in a special microscope stage with the body temperature maintained The pouch was exposed over a glass plate so that a proper condensor system could be used for transillum

nation (Fig 1) The cheek pouch was continuously irrigated with Tyrode s solution at constant temperature this is important as the circulation in the cheek pouch is extremely sensitive to dehydration and changes in temperature

Two experimental designs were used (1) production of a defect (*excision of tissue*) and (2) *deposit*

The pouch in 47 experiments was everted and the epithelium and connective tissue on one side over an area approximately 2 mm in diameter were gently removed by means of a stereomicroscope and microsurgical instruments (Fig 2) (BRANEMARK & JONSSON 1964) This procedure results in a microwound with exposure of connective tissue capillaries in the defect The medium was applied with an eye dropper and removed with Tyrode s solution after about 10 minutes For evaluating mast cell reaction the tissue was stained in vivo with 0 1 % *toluidine blue in Tyrode s solution before the application of the medium* and restained after it had been washed away

In 89 experiments 0 05 ml of contrast medium was injected into the upper layer in the cheek pouch (Fig 2) the pouch then being watched for up to 5 hours under standard environmental conditions maintained by irrigation with Tyrode s solution The *observations were made with transillumination in a modified* Leitz intravital microscope (objectives UO × 23 NA 0 55 and UO × 55 NA 0 84) with microphotographic recording of structures and microcinematographic registration of flow patterns (BRANEMARK 1962 1964 1966)

Corpuscular flow velocity was measured in a selected small venule by a comparative optic electronic method (BRANEMARK & JONSSON 1963) The tissue changes were followed continuously in the defect and deposit areas

The following contrast media were investigated

Perjodal H	Isopaque 260	Urografin 30 %
Perjodal U	Isopaque cerebral	Urografin 45 %
	Isopaque 350	Urografin 60 %
(Supplied by Pharmacia Uppsala Sweden)	*Isopaque coronar*	Urografin 76 %
		Biligrafin forte
	(Supplied by Nyegaard & Co Oslo Norway)	*(Supplied by Schering AB* Stockholm Sweden)

The number of experiments in which the contrast media were applied to tissue defects or deposited in the tissue by injection are given below

	Defect	Deposit
Perjodal *H*	*13*	*11*
Perjodal U	3	6
Biligrafin forte	3	6
Urografin 30 %	3	7

(Continued on p 552)

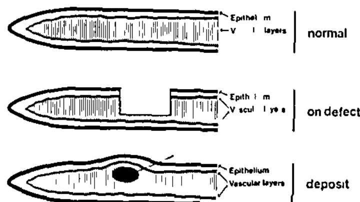


Fig. 2. Diagrammatic representation of various experimental procedures. The normal exposed cheek pouch, small tissue defects and sites of application to the tissue.

have not, however, been investigated in the studies so far performed. Nor has the actual cause of such disturbance become known. The hypertonicity of the media has been considered a possible cause of the local toxic effects but this assumption still remains to be proved. The possible role played by the interaction of the mast cells and ground substance in the physiologic mechanisms has been almost completely overlooked. The problems are complex and it therefore appears unlikely that one single method can completely clarify the causes of the disturbances in the microcirculation and the changes in permeability of the vessel wall.

Brånemark (1967), Brånemark & Goldie (1967), Brånemark et coll. (1966) in a series of investigations of tissue injury induced by different drugs applied on intact or more or less damaged microvascular systems, have shown the cheek pouch of the hamster to be well suited for screening purposes as well. This appears also to be satisfactory for the detailed analysis of physiologic mechanisms related to blood cells, plasma, endothelium, periendothelium as well as periendothelial and tissue mast cells. Changes in the microcirculation in the cheek pouch after the topical application of contrast media were first described by Jacobsson (1965).

As the further aim of the present study was to elucidate some of the still obscure tissue injury phenomena caused by contrast media, the vital microscopy of the cheek pouch of the hamster was selected as a suitable method for this investigation.

Method and Material. Hamsters weighing about 100 g were anaesthetized with nembutal 30 mg/kg i.m. The animal was immobilized in a special microscope stage with the body temperature maintained. The pouch was exposed over a glass plate so that a proper condensor system could be used for transillumi-

3a

3b

3c



Fig 3 Sequence of events in terminal arteriole exposed in a defect before application (a) 2 minutes (b) and 5 minutes (c) after the application of Urografin 45 % The flow is markedly reduced in (b) and (c) A comparison of the distribution pattern of blood discloses markedly reduced hematocrit in two precapillary branches in (b) and only plasma in (c)

Fig 4 Changes in periendothelial mast cells alongside a venule in a tissue defect after application of Urografin 45 % Condensation of the mast cells and distinct outline of the nucleus in (b) A tissue mast cell in a stage of disruption is seen in (c)

Urografin 45 %	7	8
Urografin 60 %	3	7
Urografin 76 %	3	7
Isopaque 260	3	16
Isopaque cerebral	3	6
Isopaque 350	3	9
Isopaque coronar	3	6
Total	47	89

Results

1 *Experimental defect* Application of a contrast medium, irrespective of type, was invariably followed by a transient slowing down of the flow After varying intervals of 0 5 to 4 minutes the flow through the venules, capillaries and the small arterioles stopped, first in the small venules (diameter 10 to 20 μ) then in the capillaries and the larger venules (30 to 80 μ) and finally in the arterioles (20 to 50 μ) The entire sequence of events was so rapid that discrimination of relative differences in toxicity between the contrast media studied could not be achieved by an analysis of the time factors It was obvious nevertheless that *the time interval varied with the concentration of the medium used In the* arterioles as in the venules and capillaries the flow usually stopped with packing of the blood cells in the vessels The corpuscle/plasma ratio in some of the arterioles with a diameter of about 20 μ was however sometimes markedly reduced after the application of Isopaque 260 and Urografin 45 % This decrease in intravascular hematocrit is apparent from Fig 3

Stasis, which occurs immediately, is the most striking phenomenon in the microvascular events occurring after application of the contrast medium An increase was noticed in the transparency of the cheek pouch More or less marked microvascular dilatation was observed irrespective of the type of medium applied Segmental contraction occurred in an arteriole in three cases (out of thirteen) after the application of Perjodal H, and in two cases (of three) after Biligrafin forte

After the contrast medium had been removed by washing with Tyrode s solution, blood began to flow through the vessels again, first in the larger venules, then in the smaller venules and capillaries and finally in the arterioles Here again recovery occurred sooner after the application of the lower concentration of medium but always within 5 minutes in the defects

An increased number of white blood cells were then seen along the wall of the vessel denoting a local toxic effect An increasing number of white thrombi passed through the vessels at almost the same speed as the blood cells After the application of Biligrafin forte, single thrombi, adhering to the walls of the

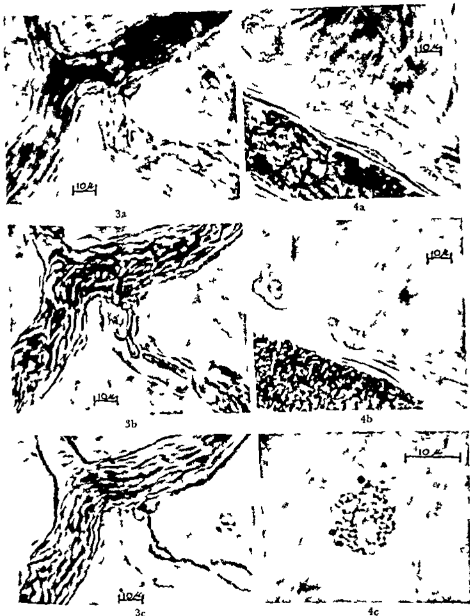


Fig 3 Sequence of events in terminal arteriole exposed in a defect before application (a) 2 minutes (b) and 5 minutes (c) after the application of Urografin 45. The flow is markedly reduced in (b) and (c). A comparison of the distribution pattern of blood discloses markedly reduced hematocrit in two precapillary branches in (b) and only plasma in (c)

Fig 4 Changes in periendothelial mast cells along the a venule in a tissue defect after application of Urografin 45. Condensation of the mast cells and distinct outlines of the nucleus in (b). A tissue mast cell in a stage of disruption is seen in (c)

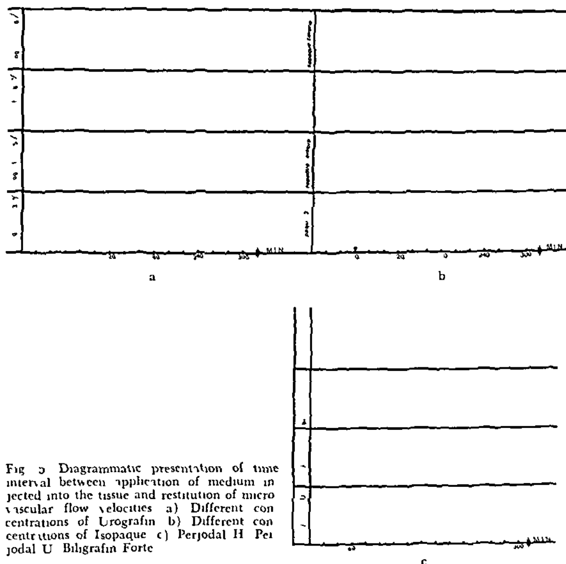


Fig 3 Diagrammatic presentation of time interval between application of medium injected into the tissue and restitution of microvascular flow velocities a) Different concentrations of Urografin b) Different concentrations of Isopaque c) Perjodal H Perjodal U Biligrafin Forte

venules and obstructing the flow, were observed This also occurred after the application of Perjodal H (in six of thirteen cases), after Urografin 76 % (in two of three cases) and Isopaque 350 (in one of three cases) These thrombi presumably consist of fibrin and platelets with occasional adherent granulocytes that slide along the endothelium Toluidine blue demonstrated that some of the mast cells were disrupted, others still retained intact boundaries with the granules abnormally large and dense but still within the cell (Fig 4)

2 *Deposit* The changes were essentially the same as those described above After the injection of the medium the rate of flow immediately decreased with

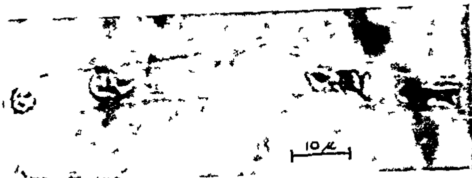


Fig 6 Abnormalities in intravascular morphology of erythrocytes illustrated by vital microphotography of a capillary in a tissue defect after application of Urografin 45 Characteristic crenation of the red cells is exhibited but the basic biconcave cellular topography is maintained

ubsequent circulatory arrest first in the small venules then in the capillaries and the large venules and finally in the arterioles A striking difference between the effect of high and low concentration of the medium was also evident in these experiments The interval between the injection and the complete cessation of flow through the venules and capillaries thus ranged from a few seconds to one minute for Urografin 60 % Urografin 76 % Biligrafin forte Perjodal H Perjodal U Lopaque 350 and Isopaque Coronar compared with 30 seconds to 5 minutes for the less concentrated media

The recovery of the circulation first appeared in the periphery of the deposit area and then spread towards the centre The time required for restitution of flow to original circulatory values varied with the concentration of the contrast medium (Fig 5) After recovery of the circulation the vessels presented signs of toxic reaction viz an increasing number of granulocytes as well as white thrombi and single thrombi adhering to and sliding along the vessel wall The adherent thrombi were observed only after the application of Biligrafin forte, Urografin 76 % and Perjodal H

The appearance of the blood was characteristic after the application as well as after the injection of the contrast medium the blood immediately became coarse and granular in appearance A higher resolution revealed that the red blood corpuscles were crenated and deformed (Fig 6) During the circulatory stand till the blood appeared structureless and homogenous The high resolution made it possible to identify the cell boundaries of only a few red blood corpuscles these cells were much deformed

Discussion

It is obvious from the literature that contrast media of now outdated type as well as newer media may cause various types of damage to the tissues.

Tissue injury is manifested by microcirculatory disturbances The underlying physiologic mechanism is also confined to the microvascular area of circulation Vital microscopy of these phenomena is an extremely sensitive method which reveals even slight tissue injury It is also well suited for the analysis of the subsequent course of tissue reaction and the possible reversibility of the lesion (BRANEMARK et coll) The results presented in this study indicate that all the media tested caused some tissue injury, as manifested by a characteristic reduction in the flow, beginning in the venules and later affecting the capillaries and the arterioles as well The tissue presents signs of injury after restitution of the flow viz an increasing number of white cells adhering to and sliding along the vessel wall and an increasing number of white thrombi passing through the vessels at almost the same speed as the blood cells and, in some cases thrombi adhering to the vessel wall The cause of the above mentioned changes in the microcirculation are not obvious from these vital microscopic studies, the crenation and deformation of the erythrocytes can probably not completely explain the changes No profound destruction of the tissue was demonstrable Probably there is some change in the plasma composition and possibly also a change in the interphase between plasma and red blood corpuscles as well as in the plasma endothelial interphase, but the exact mechanism and the nature of the process is still obscure Radiologic contrast media are highly hyperosmotic and thus hyperosmolality could probably account for part of the changes observed The pH might also play a role

It is well known that the extent and intensity of staining of mast cells vary with their content of histamine and histamine like substances and that release of histamine from the mast cells is accompanied by altered stainability of the cell We have found that after exposure to contrast media the mast cells change their morphology in a characteristic way This suggests that a liberation of histamine and histamine like substances may occur, the possibility of these substances being a factor in producing the changes in microcirculation will be the subject of a future investigation

The rapid reversibility of the microcirculatory conditions registered in the defect investigations after washing with Tyrode s solution is equally characteristic as the changes in microcirculation after application of contrast media Our observations are not in agreement with those of O CONNOR et coll (1967) that 'after a normal saline wash an unbiased observer was unable to differentiate a treated from an untreated preparation In our examinations, different degrees

of wall adhesion of granulocytes and platelets developed and different degrees and numbers of fibrin and platelet thrombi and microemboli were formed The mast cells were affected, with disruption of some cells while condensation of the granules as identified by an increase in optical density occurred in others

The present study has revealed that all contrast media exert a toxic effect on the microvascular system affecting the rheology of the circulation the intra vascular blood cells the vessel wall and the perivascular cellular and extra cellular components. Furthermore this investigation disclosed that the hamster cheek pouch is well suited for investigating the toxicity of contrast media.

Different manifestations of tissue injury were demonstrated Among these the period of time passing from the application of the contrast medium until the restitution of flow seems to be a suitable parameter for discrimination between different types of agents

SUMMARY

The effects of roentgen contrast media on microvascular structure and function when locally applied to the tissue of the cheek pouch of the hamster were studied All the drugs produced some changes in the microcirculation but certain patterns of the pathology were related to their composition The reversibility of the changes was also analysed and classed with the type of drugs tested

ZUSAMMENFASSUNG

An den Backentaschen von Hamstern wurde der Effekt von Rontgenkontrastmitteln auf die mikrovaskulare Struktur und Funktion des Gewebes studiert Alle Kontrastmittel ver ursachten Veranderungen in der Mikrozirkulation, aber es fand sich dass gewisse Ver anderungen von bestimmten Chemikalien abhingen Der Erholungsvorgang wurde ebenfalls studiert und mit dem Typ des verwandten Kontrastmittels in Bezug gebracht

RÉSUMÉ

Les auteurs ont étudié les effets des moyens de contraste radiologique sur la structure et la fonction d m rovaisseaux quand ils sont appliques localement sur le tissu de la poche de la jou du hamster Tous ces produits modifient la microcirculation certains types de modification sont en rapport avec leur composition Les auteurs ont aussi analysé et classe la rever bilite de ces modifications suivant le type des produits expérimentes.

REFERENCES

ARNESEN K Symposium on metrizoate sodium (Isopaque) a new contrast medium for angio graphy and urography Pathological — anatomical investigations Farmakoterapi 18 (1962) 9

AUSMAN J I YOUNG R and OWENS G Radiopaque dyes and other agents in the production of endothelial damage J surg Res 4 (1964) 319

BAUDISCH E und BAUMANN W Über die Beeinträchtigung der Nierenfunktion nach Nieren gefässdarstellungen Fortschr Röntgenstr 100 (1964) 592

BERG N O IDBOHRN H and WENDEBERG B Investigation of the tolerance of the rabbit's kidney to newer contrast media in renal angiography Acta radiol 50 (1958) 285

BRÅNEMARK P I Vitalmikroskopie Eine Methode fur gleichzeitiges mikroskopisches Studium von Struktur und Funktion Leitz Mitt Wiss Techn 3 (1962) 73

— Experimental biomicroscopy Bibl anat (Basel) 5 (1964) 51

— Intravital microscopy its present status and its potentialities Med biol Ill 16 (1966) 100

— Local tissue effects of sodium fluoride Odont Revy 18 (1967) 273

— and GOLDIE I Observations on the action of prednisolon tertiary butyl acetate (codelcortone TBA) and methylprednisolone acetate (depomedrone) on normal soft tissues Acta rheum scand 13 (1967) 241

— and JONSSON I Determination of the velocity of corpuscles in blood capillaries A flying spot device Biorheol 1 (1963) 143

— — A diathermy unit for microsurgical preparations Scand J clin Lab Invest 16 (1964) 119

— — ALBREKTSSON B LINDSTROM J and LUNDBORG G Local tissue effects of wound disin fectants Acta chir scand (1966) Suppl No 357

BROMAN T and OLSSON O The tolerance of cerebral blood vessels to a contrast medium of the diodrast group An experimental study of the effect on the blood brain barrier Acta radiol 30 (1948) 326

BROWN R RAHIMTOOLA S H DAVIS G D and SWAN H J C The effect of angiocardio graphic contrast medium in circulatory dynamics in man Cardiac output during angio cardiography Circulation 31 (1965) 234

FODA M T CASTILLO C A CORLISS R J et coll The intravascular pressure response in man to contrast substance used for angiocardiography Amer J med Sci 250 (1965) 390

GREITZ T and WEISS S EEG and ECG in cerebral angiography with sodium diatrizoate (Hypaque) and methylglucamine diprotrizoate (Miokon) Acta radiol 52 (1959) 115

HAMMARGREN L L GEISE A W and FRENCH L A Protection against cerebral damage from intracarotid injection of Hypaque in animals J Neurosurg 23 (1965) 418

INGVAR D H EEG during cerebral angiography Acta radiol 47 (1957) 181

ISERI L T KAPLAN M A EVANS M J and NICKEL E D Effect of concentrated contrast media during angiography on plasma volume and plasma osmolality Amer Heart J 69 (1965) 154

JACOBSSON B Rontgenkontrastmedels inverkan på kapillarbadden (In Swedish) Nord Med 74 (1965) 822

— and PAULIN S Experiences with different contrast media in coronary angiography *In* Cations in intravascular contrast media and development of specific metrizoate formulas Pharmacologic and clinical studies Acta radiol (1967) Suppl No 270 p 103

JOHNSON J H and KNISELY M H Intravascular agglutination of the flowing blood following the injection of radiopaque contrast media Neurology 12 (1962) 560

KIRKLAND J A and HASLOCK M R Transient proteinuria following intravascular injection of contrast media Lancet 1961 I p 693

LUNDERVOLD A and ENGESET A Polygraphic recordings of EEG ECG and blood pressure during cerebral angiography with Isopaque B *In* Cations in intravascular contrast media and development of specific metrizoate formulas Pharmacologic and clinical studies Acta radiol (1967) Suppl No 270 p 87

McCONNELL F and MERSEREAU W A The effect of angiographic contrast media on arterial endothelium An experimental study J Canad Ass Radiol 15 (1964) 14

MARGOLIS G and YERASIMIDES T G *Vasopressor potentiation of neurotoxicity in experimental* aortography Implications regarding pathogenesis of contrast medium injury Acta radiol Diagnosis 5 (1966) 388

— GRIFFIN A T KENAN P D et coll Contrast medium injury to the spinal cord The role of altered circulatory dynamics J Neurosurg 16 (1959) 390

MERSEREAU W A and ROBERTSON H R Observations on venous endothelial injury following the injection of various radiographic contrast media in the rat J Neurosurg 18 (1961) 289

O CONNOR J F SITZMAN S B and DEALY J B Vascular injury due to topical application of *cardiovascular contrast medium in the hamster cheek pouch* Radiology *89 (1967) 20*

READ R C and MEYER M The role of the red cell agglutination in arteriographic complications Surg Forum 10 (1959) 472

RHEA W G KILLEN D A and FOSTER J H Relative nephrotoxicity of Hypaque and Angio-Conray Surgery 57 (1965) 554

ROSS R S Clinical applications of coronary arteriography Circulation 27 (1963) 107

SALVESEN S LUND NILSEN P and HOLTERMANN H Ameliorating effects of calcium and magnesium ions on the toxicity of Isopaque sodium 1 Acute toxicities and toxicities in the brain *In* Cations in intravascular contrast media and development of specific metrizoate *formulas* Pharmacologic and clinical studies Acta radiol (1967) Suppl No 270 p 17

— — — Effects of calcium and magnesium ions on the systemic and local toxicities of the N methylglucamine (meglumine) salt of metriozoic acid (Isopaque) *In* Cations in intravascular contrast media and development of specific metrizoate formulas Pharmacologic and clinical studies Acta radiol (1967) Suppl No 270 p 180

SCHMIDT H W The behaviour of the pial vessels during and after the intracarotid injection of roentgen contrast media Acta radiol 44 (1955) 100

STEINWALL O An improved technique for testing the effect of contrast media and other substances on the blood brain barrier Acta radiol 49 (1958) 281

WIEDEMAN M P *Vascular and intra ascular responses* to various contrast media Angiology 14 (1963) 107

ZINNER C and GOTTLOB R Morphologic changes in vessel endothelia caused by contrast media Angiology 10 (1959) 207

Book reviews

AN ATLAS OF PATHOLOGIC PNEUMOENCEPHALOGRAPHIC ANATOMY By Giovanni di Chiro 555 pages Charles C Thomas, Springfield Illinois 1967 Price 49 50 dollars

This book is a continuation of the illustrated work presented by the author in 1961 under the title An Atlas of Detailed Normal Pneumoencephalographic Anatomy Its size and lay out are the same as in the previous work, i e it contains a large number of roentgenograms of approximately normal size each view being provided with a legend and with the path ologic changes marked with arrows and explanatory drawings These illustrations, also are of the same high class They demonstrate clearly that air is the best medium for studies of the outer and inner cerebrospinal fluid spaces of the brain The author has aimed at obtain ing as complete a series of examples of different pathologic conditions as possible and has placed particular importance on the expanding lesions The sections of greatest interest to more experienced neuroradiologists however are those dealing with different types of atrophy malformation and hydrocephalus No previous book has given such a complete survey of these lesions This is not surprising seeing that the author is one of the pioneers of modern hydrocephalus research The author himself complains that in order to make the work as exhaustive as possible he had to include a few illustrations that were not entirely satis factory This defect is noticed mainly in the chapter on changes below and at the level of the foramen magnum especially the films showing changes below the foramen could have been more illustrative The author in his previous work addressed himself mainly to neurologists neurosurgeons and neuroradiologists The present book is not in the same way dedicated to workers in particular fields Nevertheless it may be unreservedly recommended to the same categories and particularly to neuroradiologists in training

G Westberg

RADIOGRAPHIC PROCESSING IN MEDICINE AND INDUSTRY By D H O John 292 pages 53 figures 8 plates and 18 tables The Focal Press London and New York 1967 Price £5 5s 0

The room for processing is usually the last to be considered in planning the roentgen department very often it is crowded into the last available bit of space wrote J Kingdom in Radiography in 1959 Maybe this is not often so true today as it was in the past

An introductory chapter on dark room planning discusses centralization and decentral ization This is more important than ever as the new small roller machines are so small and relatively cheap that decentralization is often the ideal solution A conventional dark room is today definitely old fashioned and the new units have led to new methods of plan ning Large parts of the first chapter refer to manual processing and may be considered less up to date The principles of and the new possibilities with the new machines should have been discussed in much more detail The chapters on sensitive materials screens processing chemistry, regeneration and special developing methods are clear and informative and contain good diagrams and graphs Certain special procedures as for instance xerography are mentioned The properties of the developed image are discussed on the basis of sensito metry Problems of fog and faults that might arise during manufacture storing or handling are discussed and examples are given Literary references are appended to each chapter and a special bibliographic and literature section gives further information about books and available photographic and radiographic journals A formulary appendix and tables on function of automatic processing units are included

Ove Mattsson

Subject index to Volume 8 — Diagnosis

ROENTGEN DIAGNOSIS

Nervous system

Digestive tract (incl biliary tract and spleen)

Heart and Vessels (incl lymphatic vessels)

Lungs, Pleura, Mediastinum and Chest walls

Bones and Joints (incl soft tissue)

Ear, Nose and Throat

Ophthalmology

Uro Genital system

RADIOACTIVE ISOTOPES

TECHNIQUE

CONTRAST MEDIA

MISCELLANEOUS

BOOK REVIEWS

List of Authors

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Nos 173—292

(Issued November 1969)
For Suppl Nos 1—172 inclusive, see list issued December 1960 in Vol 54 fasc 6

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